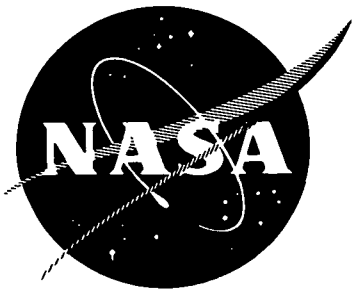
Research and Technology Operating Plan



SUMMARY

FISCAL YEAR 1976
RESEARCH AND
TECHNOLOGY PROGRAM

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

This Supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, for $3.50. For copies mailed to addresses outside the United States, add $2.50 per copy for handling and postage.

INTRODUCTION

This publication represents the NASA Research and Technology program for FY 1976 It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Operating Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and abstracts of the RTOPs. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

The RTOP Number Index provides a cross-index from the RTOP number assigned by the NASA responsible organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary*.

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contacts which might be disruptive to on-going research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Washington, D.C. 20546
Attn: Roy L. Daisey
Resources and Management Division (RMP)

Dr. A.M. Lovelace
Associate Administrator for
Aeronautics and Space Technology

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Office of Aeronautics and Space Technology

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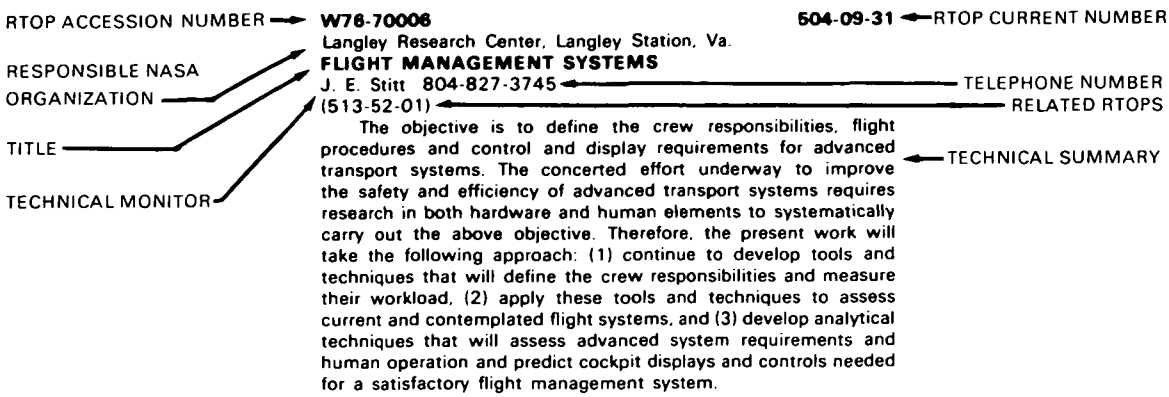


RESEARCH AND TECHNOLOGY OPERATING PLAN

a summary

FISCAL YEAR 1976

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

W76-70001 **504-09-11**
Langley Research Center, Langley Station, Va.
HUMAN RESPONSE TO NOISE
R. R. Heldenfels 804-827-2043

The objective of this work is to define and quantify properties of aircraft noise that cause community annoyance. Included is the development of research evaluation techniques and measuring scales along with accomplishment of research to assess effects of aircraft noise on sleep, speech interference, and performance. FY-76 effort, along with limited contract/grant studies, will be directed toward studies concerned with noise annoyances, background noise, low frequency noise, speech/communication effects, sleep/performance effects, anxiety/fear, and multi-event noise exposures. A downstream goal of this program is to develop a model for reliable prediction of response of people to aircraft-generated noise.

W76-70002 **504-09-12**
Ames Research Center, Moffett Field, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - TECHNOLOGY ASSESSMENT
H. P. Klein 415-965-5094
(504-09-11)

The objective of this program is to develop an understanding of the social and psychological effects of large scale technological innovations, as exemplified by air transportation systems, and to attempt to model such effects so as to impact the design of these systems. To achieve this objective studies of both the short and long term social impacts (including psychological, political, environmental, and economic) of air transportation as an element of the total transportation system will be continued. Field studies of existing systems will be conducted as needed to meet the objectives. Supporting work developing theory and methodology for assessing community acceptance of aircraft operations and social and psychological impact of related technologies will be conducted.

W76-70003 **504-09-13**
Langley Research Center, Langley Station, Va.
AIRCRAFT INTERIOR NOISE REDUCTION
R. R. Heldenfels 804-827-2043

The objective is to develop the technology needed to reduce aircraft interior noise levels to achieve increased operating safety, hearing protection, and comfort of crew and passengers with minimum weight and cost penalties. The noise sources for STOL, helicopter, and general aviation aircraft will be determined from this as well as other ongoing programs. In addition, the transmission of the noise through the structure and the transmission paths will be determined. Structural designs will be investigated which have more acceptable transmission characteristics with minimum weight penalties. A parallel effort will determine acceptable levels of interior noise for safety and comfort of crew and passengers. Full-scale flight tests will be made incorporating noise reduction concepts to verify the technique and the passenger/crew acceptability.

W76-70004 **504-09-21**
Langley Research Center, Langley Station, Va.
RIDE QUALITY
R. R. Heldenfels 804-827-2043

The objective is to define and qualify those ride-environment properties, particularly motion, cabin noise, and vibration, that determine ride quality and associated passenger acceptance pertaining to air transportation systems. To achieve these objectives research studies will be conducted to develop data appropriate for establishing criteria for ride-environment requirements and for aircraft operational limits relevant to aircraft attitude, accelerations, interior noise level, and angular motions. Included are: field studies to obtain data aboard scheduled airline systems as well as other vehicles; studies under controlled conditions aboard research aircraft including in-flight simulators; laboratory studies using ride-motion simulators under very closely controlled conditions; and analytical studies of experimental data to model the phenomena and to develop criteria. Supporting effort will be carried out to develop appropriate study methodology, subjective response opinion questionnaires, portable ride-measuring instruments, laboratory simulators, and analytical procedures.

W76-70005 **504-09-22**
Ames Research Center, Moffett Field, Calif.
RIDE QUALITIES CRITERIA VALIDATION/PILOT PERFORMANCE DURING LOW ALTITUDE HIGH SPEED FLIGHT
H. P. Klein 415-965-5094

ARC, FRC and LRC are continuing to evaluate the B-1 airplane for possible research areas which will contribute to advanced technology of interest to NASA. The B-1 is considered to be an available test facility providing flight information not readily available from other sources. Tentative research areas have been identified as follows: structural mode control/ride quality; pilot performance during manual terrain following; transonic aeroelastic loads measurement; inlet/engine compatibility; aft nacelle aerodynamics; new subcritical flutter prediction technique. This RTOP is for the Ride Qualities Criteria Validation/Pilot Performance During Low Altitude High Speed Flight only. Specific objectives are to: (a) validate/refine current ride qualities criteria, and (b) develop pilot/vehicle systems models which account for the effects of ride qualities, handling qualities and display configuration on pilot terrain - following performance. Results from ongoing and planned Rockwell Inc. simulation and flight tests will be analyzed with the above objectives in mind. If practicable, NASA recommendations regarding simulator and/or flight experiment

protocol and instrumentation will be implemented to maximize utility of results for NASA objectives.

W76-70006 **504-09-31**
Langley Research Center, Langley Station, Va.
FLIGHT MANAGEMENT SYSTEMS
J. E. Stitt 804-827-3745
(513-52-01)

The objective is to define the crew responsibilities, flight procedures and control and display requirements for advanced transport systems. The concerted effort underway to improve the safety and efficiency of advanced transport systems requires research in both hardware and human elements to systematically carry out the above objective. Therefore, the present work will take the following approach: (1) continue to develop tools and techniques that will define the crew responsibilities and measure their workload, (2) apply these tools and techniques to assess current and contemplated flight systems, and (3) develop analytical techniques that will assess advanced system requirements and human operation and predict cockpit displays and controls needed for a satisfactory flight management system.

W76-70007 **504-09-32**
Ames Research Center, Moffett Field, Calif.
AIRCREW PERFORMANCE AND AVIATION SAFETY
H. P. Klein 415-965-5094
(515-51-11; 504-09-33; 505-08-23)

The objectives of this program are to investigate current problems in pilot training, performance measurement and evaluation, and communications between flight crewmembers and other components of the aviation system. General aviation and civil air transport operations will be considered. Specific objectives are: (1) develop objective, precise, and stable measures of aircrew performance for use in research and operational training programs; (2) develop new technology and methodology for training necessary flight crew skills; and (3) explore fundamental problems in the transfer of information to pilots from other components of the aviation system, e. g., navigation charts, and cockpit warning systems. To achieve these objectives GAT-1 simulator will be modified to permit full-mission simulation capability and automated performance monitoring. This facility will be used to examine pilot behavior, especially cognitive or decision-making behavior, and to evaluate alternative methods of human performance measurement. The effectiveness of various candidate solutions for identified training problems will be evaluated using both formal experimental evaluations, and more informal feasibility demonstrations (pilot projects). Specific problems in the transfer of information between pilots and other components of the present aviation system will be used to identify fundamental problem areas, and to develop and evaluate potential solutions.

W76-70008 **504-09-34**
Flight Research Center, Edwards, Calif.
FLIGHT MANAGEMENT IN REMOTE PILOTED SYSTEMS
W. R. Winter 805-258-3311

This flight test program is primarily to develop and evaluate an integrated system for pilot control of remote piloted vehicles. The pilot task load will be analyzed and correlated with the psychophysiological response of the aircrew during the development of the RPV system. The general objective is to define operator/system interactions, flight procedures in control and display requirements for remote piloted vehicles to be used as training simulators and as active flight vehicles. The specific objectives are define and correlate major workload with observed response to form predictive performance models: (2) evaluate RPV cockpit configuration pilot responses, and display and control variations to optimize simulation effectiveness and remote operation efficiency to include horizontal landing. While developing and utilizing RPV techniques, cockpit configurations will be systematically varied while the effects upon pilot response are tabulated.

W76-70009 **504-09-41**
Langley Research Center, Langley Station, Va.
FLIGHT SIMULATION TECHNOLOGY - SIMULATION TECHNIQUES
J. E. Stitt 804-827-3745

The objective is to contribute to the technical advancement of flight simulators as applied to aeronautical research, development, and flight training. New operational requirements for simulators to support Langley Research Center programs provide the motivation and laboratory environment for significant contributions to the advancement of simulation technology. Interagency involvement with the application of the Differential Maneuvering Simulator also provides valuable insights into the needs for improved simulator capability for flight training and pilot proficiency, as well as for the support of research programs. This RTOP will cover both in-house and contractual studies which address current constraints in simulator equipment, the formulation of simulation math models, and the linkage of the two to provide effective simulations. Results of the effort will be documented in NASA Technical Notes and contractor reports and will be applied to simulation of interest to Langley Research Center.

W76-70010 **504-09-42**
Ames Research Center, Moffett Field, Calif.
SIMULATION TECHNOLOGY FOR AERONAUTICS
H. P. Klein 415-965-5094
(504-09-32; 504-09-33)

The objective of this RTOP is to provide a scientific and technical base of information that will allow the valid, reliable and economic substitution of simulators for actual flight operations in aeronautical research, development and crew training. Specific objectives are: (1) provide an understanding of pilots' perception and processing of complex visual, motion and other stimuli, with emphasis on how these relate to the fidelity of complex visual scene generation techniques; (2) provide task related criteria for vision and motion simulator systems; (3) develop compensation techniques to obtain the motion simulator performance required for various simulation tasks; (4) provide engineering development and evaluations of advanced computer driven visual displays; and (5) develop a Simulation Facilities User's Guide. In-house perception studies will be continued with emphasis both on characterizing human perceptual response characteristics and developing experimental techniques for measuring the fidelity of simulator displays. An in-house study of the effect on pilot performance caused by the phase lags in the simulation (computer, motion, visual) will be initiated. An analytical model of the motion simulator will be developed. Both in-house and contract studies will be continued (or in some cases initiated) to further the development of promising techniques for scene technology. A Simulation Facilities User's Guide will be completed.

W76-70011 **505-01-11**
Lewis Research Center, Cleveland, Ohio.
RELATIONSHIP OF ATOMIC STRUCTURES TO MATERIAL PROPERTIES
H. B. Probst 216-433-4000
(505-01-12)

The broad objective of this work is to gain a better understanding of the basic structure and behavior of metallic and nonmetallic materials. The ultimate value of such an improved understanding will be in its utilization to produce new and improved materials particularly for aeronautics applications. The approach taken to achieve this improved understanding is to conduct basic research in three broad classes of high temperature materials; these are alloys, coatings, and ceramics. A more complete understanding of the mechanism of oxide dispersion strengthening in Ni, Ni-Cr, and Ni-Cr-Al alloys will be sought. The solidification process in directionally grown Ni-base eutectics will be examined. A better understanding of the occurrence of segregation and of the relationship between eutectic structural variables and mechanical properties will be sought. The kinetics of coating formation and degradation of aluminide coatings will be studied. Silicon carbide ceramics will be investigated to improve our knowledge of the relationships between processing, structure, and mechanical behavior.

W76-70012 **505-01-12**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PROPULSION MATERIALS
H. B. Probst 216-433-4000
(505-01-11)

The objective of this RTOP is to provide improved materials, both metallic and nonmetallic, for use in advanced air-breathing power plants, particularly for aeronautical applications. Materials are sought that offer improvements not only in technical performance but also in economy in terms of costs and life. The classes of materials to be investigated include directionally solidified eutectics, dispersion strengthened alloys, protective coatings, and ceramics. Property improvements are sought by basic changes in materials per se, e.g., alloy compositional changes, and by process changes applied to existing and new materials. Material improvements are judged by measurements of mechanical and physical properties as well as qualitative evaluations of microstructural features and performance in simulated-engine environments. Ultimately, highly promising materials and processes that result from this program become candidates for the MATE program to accomplish scale-up and full scale engine testing.

W76-70013 **505-01-21**
Lewis Research Center, Cleveland, Ohio.
FATIGUE, FRACTURE, AND LIFE PREDICTION
M. H. Hirschberg 216-433-4000

The major objective is to obtain a better understanding of the failure or fracture mechanisms that are involved in the application of advanced materials to aeronautics structures or propulsion systems. A second major objective is to develop methods for predicting the life of specimens or components when they are subjected to constant temperature and monotonic loads or to complex patterns of temperatures and cyclic loads as a function of time. To achieve these objectives, research is underway to extend existing life prediction techniques and analyses, and to develop new methods for determining the stress and strain distributions in the vicinity of discontinuities such as flaws or cracks, as well as to understand the reaction of advanced materials to these discontinuities when subjected to various environmental conditions. Various approaches are also being examined for predicting the time to initiation of the first detectable cracks as a result of mechanical and thermal fatigue and to predicting the propagation rate of these cracks. Standard test methods and specimens are being developed to properly characterize the fatigue and fracture behavior of materials and to provide background information for rational design procedures.

W76-70014 **505-01-21**
Ames Research Center, Moffett Field, Calif.
FATIGUE, FRACTURE & LIFE PREDICTION
D. R. Chapman 415-965-5065

The objective is to develop the basic understanding required to capably select materials and to reliably predict the life of engineering structures exposed to potentially degrading chemical environments through the study of the following programs: the prediction of time-dependent fracture of structural metals caused by subcritical crack growth, the study of the mechanisms of failure of fibrous composite materials, and the definition of stress-corrosion cracking of iron, nickel, aluminum and titanium base alloys in anticipated service environments. Experiments will be conducted on metals under conditions of static and cyclic loading in a variety of environments to determine the mechanisms and kinetics involved in the process of environmental embrittlement. Experiments will also be conducted on fibrous composite materials to determine the relation of load characteristics and the properties of matrix, fiber and interface to the failure behavior. Also, tests will be performed on alloy steels being considered for high strength aeronautical applications to determine the incubation period for crack growth as a function of parameters of service environment. In all cases, the experiments will be related through appropriate analyses to the responsible failure mechanisms. Where possible, these results also will be related to anticipated situations.

W76-70015 **505-01-31**
Ames Research Center, Moffett Field, Calif.
FIRE-RESISTANT, NON-TOXIC POLYMERS
D. R. Chapman 415-965-5065
(505-08-21)

The objectives are: (1) to develop fire-resistant materials for increasing the survivability in commercial and military aircraft; (2) to synthesize new and improved high temperature polymers such as polyphosphazine, elastomers, polycarbonates, bismaleimides and high temperature adhesives; (3) to evaluate the toxicity of the gaseous thermal degradation products of these and other polymers; (4) to select polymers based on criteria such as flammability and limiting oxygen index and to utilize these polymers in the fabrication of fire-resistant composites; and (5) to evalute the response of different kinds of detectors toward the pyrolysis products of various polymers. To achieve these objectives fire-resistant polymers will be synthesized for potential use in aircraft. Typical polymers will include polycarbonate films, bismaleimide resins, high temperature adhesives such as polyimides and epoxies, polyphosphazines and others. The thermochemical and thermophysical properties of these polymers will be determined. Low density polymeric composites will be developed, and their thermophysical properties evaluated. State of the art detectors will be evaluated by determining their response to the pyrolysis and combustion products of polymers and composites.

W76-70016 **505-01-32**
Ames Research Center, Moffett Field, Calif.
FIRE-RETARDANT AND LASER COUNTERMEASURE MATERIALS FOR MILITARY PROGRAMS
D. R. Chapman 415-965-5065
(505-01-31)

The objectives are: (1) to apply state of the art and advanced aerospace derived fire-retardant and laser resistant materials and technology developed at NASA Ames to support current and future DOD survivability programs and other related military efforts; (2) to identify the chemical and physical mechanisms of the ablation of the transparent polymers EX-112 and EX-4F9 in various laser environments; (3) to study the reaction parameters governing the thermal decomposition of the polymers at high heating rates and to ascertain the physical phenomena, such as char swelling, internal gas generation and mechanical spallation, (from the performance of the EX-112 and EX-4F9, concepts are to be established to suggest improved laser resistant materials for a pulsed laser environment); (4) to study the processing parameters of the EX-112 and EX-4F9 necessary to make an aircraft canopy. To achieve these objectives assistance will be provided the military to reduce the vulnerability of flight and missile systems when subjected to an induced fire environment and to provide laser hardened materials for selected applications. The transparent polymers EX-112 and EX-4F9 will be characterized as to molecular form and thermal-chemical properties. Emphasis will be placed on the exact molecular form, functional groups and degree of crosslinks within the polymer. The mechanism of degradation of these polymers will be investigated as a function of heating rate using a thermo-gravimetric analyzer.

W76-70017 **505-01-34**
Lewis Research Center, Cleveland, Ohio.
COMPOSITES
R. H. Kemp 216-433-4000
(743-32-24)

The overall objective of this research is to develop fiber and laminate composite materials, structures, and components for various aeronautical propulsion applications. The higher mechanical properties and reduced weight of the composites in comparison to monolithic engineering materials make them particularly attractive for advanced turbine engine components such as fan and compressor blades, fan frames, guide vanes, and sound suppressors. Recent payoff studies show that the application of composites to these components is highly cost-effective. Composites being considered include resin matrices reinforced with graphite, boron, Kevlar 49, and glass fibers. In addition, aluminum and titanium matrices reinforced with boron and SiC fiber are being studied for temperatures beyond the capability

of the resin matrices. In the resin matrix work, emphasis is placed on the development of processable polyimides and polyphenylquinozalines to provide increased temperature capability over the conventional epoxy materials. In the metal matrix work, emphasis is placed on the development of fabrication processes and the improvement of impact resistance. A further objective of the research is to develop fire retardant polymers for use as matrix materials having low or no toxic combustion products.

W76-70018 **505-01-34**
Langley Research Center, Langley Station, Va.
COMPOSITES AND ADHESIVES
R. R. Heldenfels 804-827-2042

The objective is to develop new or improved lightweight polymeric composite and metallic materials that have longer lifetimes, greater reliability and improved structural efficiency in aeronautical structures. The work will consist of research aimed at improvement of structural resins and adhesives through systematic variation in the polymer molecular structure, determination of behavior of new or advanced filamentary composite materials containing either resin or metal matrices, and development of new or improved fabrication methods for metal-matrix and resin-matrix composite materials. Research will also be directed at repair technology of composites including detection of flaws, determination of critical flaw sizes, development of appropriate repair procedures, and evaluation of the effectiveness of the repairs on composite behavior. Studies of interfacial reactions and diffusion processes in advanced metal-matrix composites with emphasis on degradation as a function of temperature, stress and environmental corrosion will also be made. These studies will help to identify new or advanced materials for aeronautical structural applications and will provide important data on the behavior, capabilities and limitation of such materials.

W76-70019 **505-02-12**
Flight Research Center, Edwards, Calif.
HYPERSONIC VEHICLE STRUCTURES TECHNOLOGY
Roger A. Fields 805-258-3311

The program will attempt to experimentally validate significant hypersonic-vehicle structural concepts and investigate flight-loads measuring techniques for these structural concepts as they apply to the HRA.

W76-70020 **505-02-12**
Langley Research Center, Langley Station, Va.
HYPERSONIC VEHICLE STRUCTURES
R. R. Heldenfels 804-827-2042
(505-05-41)

The objective is to explore thermal/structural concepts for future hypersonic aircraft, and derive analysis and design methods applicable to such concepts. Research and development is being carried out to establish a technology base from which the structures and thermal control systems for hypersonic vehicles can be designed. Included in the program are both experimental and analytical efforts on engine and airframe structure concepts which will withstand the rigors of extended and repeated use in a hypersonic environment. Research data obtained from both laboratory and wind tunnel experiments will serve to verify design and analysis methods, establish design guidelines, and provide guidance for future research efforts.

W76-70021 **505-02-13**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION CRASHWORTHINESS
R. R. Heldenfels 804-827-2042

The objective is to create and evaluate advanced structures concepts, develop technology for improving aircraft crashworthiness, and derive analysis and design methods for aircraft structures. This RTOP is the NASA portion of a joint FAA/NASA General Aviation Crashworthiness Program to provide the analyst or designer with a proven analytical methodology for prediction of collapse of a structure under crash conditions. To achieve the objective, analytical and experimental studies will be performed to define the basic mechanisms involved in crash behavior. This technology, coupled with research on improved energy dissipation concepts will be applied to current general aviation aircraft to evaluate potential improvements in survivability for specific crash envelopes. There are three basic areas of research in this program: full-scale crash simulation testing, nonlinear structural analyses necessary to predict total collapse of the vehicle, and evaluation of energy absorption concepts for specific component design. Both analytical and experimental methods will be used to develop expertise in these three areas. Analyses will include both simplified procedures for estimating energy absorption capabilities and more complex computer programs for analysis of general airframe response. Under the crash program these analyses will be developed to provide the designer with methods for predicting accelerations, load, and displacement histories of collapsing structures. Full-scale tests of typical structures as well as tests on structural components will be used to verify the analyses and to demonstrate improved design concepts.

W76-70022 **505-02-14**
Langley Research Center, Langley Station, Va.
COMPUTER-AIDED DESIGN METHODS
R. R. Heldenfels 804-827-2052
(506-17-21; 743-01-01; 743-01-11)

Develop advanced computer-aided analysis and design methods for design of aircraft structures. Develop analysis techniques with the generality and efficiency required for the iterative calculations involved in sizing structural members. Develop and evaluate algorithms to accomplish structural sizing to meet constraints including strength, stiffness, aeroelasticity, thermal stresses, and minimum gage. Evaluate and define best architecture of structural analysis and design systems and evolve specifications for the component technical computational modules in such systems.

W76-70023 **505-02-21**
Ames Research Center, Moffett Field, Calif.
LOADS, AEROELASTICITY, AND STRUCTURAL DYNAMICS
R. H. Petersen 415-965-5880
(506-17-31; 506-17-32; 516-51-02; 743-05-01)

The objective of this research is to provide improved prediction methods and data that apply to several dynamic load and aeroelasticity problems involving aircraft. In the area of dynamic loads, investigations will be conducted to study the flow fields and pressure fluctuations within and in the vincinity of cavities (such as open ports and bomb bays), protuberances, and turrets on aircraft. Means of eliminating cavity resonances and alleviating high-intensity local dynamic loads will be sought. With respect to aeroelasticity, both analytical and experimental investigations will be conducted to develop and validate computational methods for prediction of panel flutter including the effects of the boundary layer. Improved methods for predicting aeroelastic loads will be incorporated in FLEXSTAB including gust loads and active control loads capability. Experimental investigations of unsteady pressures on oscillating 2-dimensional wings will be investigated at transonic speeds and studies will be conducted of the flutter and divergence of oblique wings.

W76-70024 **505-02-21**
Langley Research Center, Langley Station, Va.
LOADS, AEROELASTICITY, AND STRUCTURAL DYNAMICS
R. R. Heldenfels 804-827-2042

In order to predict flutter and other aeroelastic phenomena more accurately, research will be conducted to improve aeroelastic analysis methods, to provide accurate unsteady transonic aerodynamics, and to validate rotor dynamic analysis. The feasibility of increasing the Mach number range of the transonic dynamics tunnel will be explored. In order to improve and validate aeroelastic loads analysis programs, various load prediction techniques (including FLEXSTAB) will be evaluated and improved for integration into computer systems such as ATLAS and IPAD. In order to develop methods for predicting acoustic loads, structural response, and noise transmission through aircraft structures, methods for analyzing panel response with a thick boundary layer will be developed and compared with experiment. Noise transmission through aircraft structures will be studied.

The objective of these efforts is to provide the technology necessary to increase aircraft performance and extend service life and to improve aircraft safety and ride quality through improvements in methods for predicting loads, aeroelastic effects, and structural response.

W76-70025 **505-02-22**
Flight Research Center, Edwards, Calif.
DAST (DRONES FOR AERODYNAMIC AND STRUCTURAL TESTING)
Berwin M. Kock 805-258-3311
(505-06-44; 505-02-02)

Project DAST (Drones for Aerodynamics and Structural Testing) is a technology development program that will provide data that will lead to a better understanding of unsteady aerodynamic loads and flutter at transonic speeds. The program is a combined theoretical, wind-tunnel and flight-test activity and is a joint LaRC/FRC program. The flight-test activity is the subject of the RTOP. A supercritical wing will be installed on a Firebee 2. This wing will be at a planform representative of transport aircraft. The wing will be designed to be flutter critical within the normal flight envelope of the modified Firebee II. A system will be installed to provide the necessary flutter damping. The vehicle will be instrumented to measure wing pressures, accelerations, and strains. The vehicle to be modified will be the Firebee 2 used in the capability development program currently underway at FRC.

W76-70026 **505-02-22**
Langley Research Center, Langley Station, Va.
DAST (DRONES FOR AERODYNAMIC AND STRUCTURAL TESTING)
R. R. Heldenfels 804-827-2042

The objective is to provide the technology necessary to increase aircraft performance and extend service life, and to improve aircraft safety and ride quality, through improvements in methods for predicting loads, aeroelastic effects, and structural response. The approach is to provide flight data for comparison with results from various prediction methods and for cases where analyses are known to be inadequate. Emphasis will be on measurements of transonic aerodynamic loads and flight demonstrations of active control systems for load alleviation and flutter suppression. Flight testing techniques will be developed using drone-type vehicles to gather the desired data. An aeroelastic research wing will be provided with its flutter boundary within the flight envelope when flown on a Firebee II vehicle. First flights will be aimed at measuring aerodynamic loads in the transonic range, then active control systems will be incorporated for flight assessments of their performance in alleviating loads and suppressing flutter. Flights will be made cooperatively with the Flight Research Center.

W76-70027 **505-02-23**
Flight Research Center, Edwards, Calif.
FLIGHT LOADS MEASUREMENT TECHNIQUES
J. M. Jenkins 805-258-3311

Two problems are currently being addressed through the resources of this RTOP. Work is continuing toward developing a solution to the problem of weldable strain gages having a deleterious effect on the fatigue life of super-alloys and titanium alloys. Weldable strain gages have the most favorable high temperatures characteristics. Using on R and D contract, methods to accomplish a metal to metal attachment for weldable strain gage configurations to super-alloys and titanium alloys. Work has begun on a detailed examination of the problems of assessing the accuracy of flight load measurements. It is known that calibration philosophies developed in the fifties are not valid for complex structures and for composite structures. Work has begun to examine delta wing load calibration results for potential philosophical modifications to the load calibration procedure.

W76-70028 **505-02-24**
Flight Research Center, Edwards, Calif.
FLIGHT RESEARCH OF A STRUCTURAL MODE CONTROL SYSTEM (SMCS I.E., MODAL SUPPRESSION SYSTEM)
Jim M. Mckay 805-258-3311
(505-02-24)

An investigation is underway on the improvements in total dynamic response of a flexible aircraft and the potential benefits to ride qualities, handling qualities, crew efficiency, and reduced dynamic loads on the primary structure. The effectiveness and performance of the SMCS which uses small aerodynamic surfaces at the vehicle nose to provide damping to the structural modes will be evaluated.

W76-70029 **505-02-25**
Flight Research Center, Edwards, Calif.
B-1 FLIGHT LOAD MEASUREMENT RESEARCH
Alan L. Carter 805-258-3311

The objectives of this research are to evaluate airload measurement techniques on large flexible aircraft, and to evaluate newly developed computer programs for aeroelastic analysis. A joint NASA-contractor program will be conducted in which (1) point load strain gage calibration accuracy will be evaluated using data recorded during static tests of the instrumented flight load survey aircraft; (2) strain gage load measurement accuracy will be evaluated through comparisons with in flight pressure survey results; and (3) NASTRAN and FLEXSTAB predictions will be evaluated through comparisons with wind tunnel, ground and flight test results. The contractor will be responsible for acquiring and documenting the test data and modeling the aircraft in NASTRAN and FLEXSTAB. NASA will perform strain gage calibration research, NASTRAN and FLEXSTAB analysis and report the final results.

W76-70030 **505-02-31**
Langley Research Center, Langley Station, Va.
FATIGUE AND FRACTURE
R. R. Heldenfels 804-827-2042
(506-17-02; 743-01-01)

The research is conducted through a combination of analytical development, experimentation, and supplementation of in-house work by contracts and grants. Some specific goals are to improve fatigue life prediction techniques, to devise ways to predict the residual strength of reinforced sheet structures, to assess the feasibility of compressing test time during the measurements of fatigue lives of aerodynamically heated structures, and to devise and apply the reliability methods to aircraft structures where the number of structures tested is limited by cost and where measured parameters must be revised according to new data acquired during fleet operation. To the degree possible, the work anticipates the design problems and materials that will be encountered by advanced subsonic and supersonic aircraft, rotary-wing aircraft, and vertical- and short-take-off-and-landing aircraft.

W76-70031 **505-02-41**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATION TO AIRCRAFT STRUCTURES
R. R. Heldenfels 804-827-2042
(505-01-34; 510-51-01; 743-01-22)

The objective is to conduct research on composite materials to resolve problems that may hinder their application, to develop the technology required for their utilization in future aircraft structures, and to establish confidence in the use of composites through longtime flight service of structural components on commercial transport aircraft and Army helicopters. The work consists of the following: (1) Develop analytical methods to improve understanding of composite materials; evaluate behavior under various environmental conditions; develop concepts, fabrication, and nondestructive evaluation technology. (2) Fabricate and test critical components to demonstrate performance. (3) Conduct engineering studies to determine applicability of composites in primary or secondary structures of commercial or military aircraft. (4) Establish repair techniques for flawed or damaged structure. (5) Develop applications to operational aircraft such as the CH-54B helicopter, 737, L-1011, and DC-10 commercial transports. (6) Determine maintenance experience with flight service applications. Both in-house and contractual efforts will be undertaken. The results of these studies will provide new technical information and flight-service experience that will

develop confidence required to permit early application of filamentary composites in aircraft structures.

W76-70032 **505-02-42**
Langley Research Center, Langley Station, Va.
DESIGN TECHNOLOGY FOR COMPOSITE STRUCTURES
R. R. Heldenfels 804-827-2042
(505-02-11)

The objective is to advance the technology of filamentary composite structures which will provide the potential of a 25% weight reduction by conducting analytical and experimental laboratory investigations of selected components. Advanced methods of predicting the strength and stability of laminates, panels and stiffened components will be applied to new test data. Analysis will be applied to define the limitations of conventional test methods, and to develop more satisfactory test methods. Development of a strong in-house program for design and test of aircraft components will be continued. Designs for wing compression covers will be developed using advanced methods. A large series of graphite panels with either open or closed sections will be designed, fabricated and tested in the LaRC Structures Laboratory. Effort will include industry-developed as well as NASA-developed designs. Data will be generated over a large range of loading to provide a substantial NACA-type data bank upon which to base designs. A parallel program for wing shear webs will be continued. Optimum design curves will be developed over a wide loading range for both sandwich and stiffened shear web designs. Maximum strength of large graphite webs will be determined in a series of tests at Langley. In the first quarter of FY 76, data from a large series of low velocity impact tests of stressed and unstressed sandwich structure will be published. Residual strength data for impact-damaged graphite, Kevlar and hybrid laminates has been obtained.

W76-70033 **505-02-43**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE FAN BLADE STRUCTURAL ASPECTS
R. H. Johns 216-433-4000

The general objective of this program is to develop the structures technology required to provide foreign-object-damage (FOD) resistant composite fan blades. Both resin-matrix and metal-matrix composites will be considered. Fibers investigated will include graphite, boron, Kevlar, and glass; matrix materials considered will include epoxy, polyimide, and aluminum. The hybrid composite concept will continue to be developed to maximize the impact resistance to satisfy foreign object damage requirements. Combinations of fibers, orientations of multiple laminates, and fabrication techniques will be evaluated to maximize toughness consistent with other design requirements such as strength and aeroelastic response. Static impact testing and single blade whirling arm rig tests will be used to compare and evaluate different concepts and assure adequacy of final design and materials selection.

W76-70034 **505-03-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
BASIC NOISE RESEARCH
R. R. McDonald 213-354-6186

The general objectives of this RTOP are (1) to characterize the fluctuating quantities and obtain a relationship between the fluctuations and the intensity and frequency spectrum of the noise radiated from jets, (2) to find methods of reducing jet noise by controlling the shear noise sources, and (3) to determine how core flow disturbances increase the radiated noise from jets with the ultimate goal of developing efficient means of reducing jet noise emission by reducing core flow disturbances. Experiments of supersonic jets over a temperature range up to about 1500 F are conducted in an anechoic chamber. The turbulent eddies are characterized in terms of cross-correlations of the fluctuating density obtained from the detected signals of crossed-laser beams set up as a Schlieren system. Comparisons are made of the density cross-correlation function integrated over the volume of the jet with that determined from the noise signals detected by pairs of microphones located outside the jet. The effects of core flow disturbances which will be examined are entropy fluctuation interactions. These interactions will be induced by introducing pressure fluctuations as well as rapidly alternating carbon dioxide and air flows into the plenum located upstream of the nozzle. Spectral intensity of the radiated noise will be compared with the induced composition fluctuations. Pressure and composition disturbances within the plenum will also be monitored. The experimental work will be supported by analytical studies.

W76-70035 **505-03-11**
Langley Research Center, Langley Station, Va.
BASIC NOISE RESEARCH
R. R. Heldenfels 804-827-2042
(505-03-21; 504-09-11)

The objective of this research is to provide a data and technology base for reducing aircraft propulsion generated noise with minimum weight, performance, and economic penalties. Included in this objective is the identification and location of sound sources in flow fields, and in situations where aerodynamic flows interact with surfaces; atmospheric propagation including refraction and scattering; the improved efficiency of acoustic suppression materials and treatment technology; and the development of a unified data acquisition system. Both theoretical and experimental studies are involved and work will be accomplished in-house and by grants and contracts. Emphasis is placed on substantially improving analytical and experimental methods as well as equipment and facilities for subsonic and supersonic jet noise research aimed at optimizing jet exhaust noise suppressor designs. The effects of the atmosphere on noise propagation will be studied using instrumented towers and outdoor instrumented ranges to correlate acoustic and atmospheric phenomena. This work will also include precision measurements and calculations of the sound fields inside finite ducts with airflow, with varying cross sectional areas, and with and without acoustic treatment materials. Results of in-house analytical duct propagation and radiation studies, acoustic measurements in the ANRL flowing impedance tube and flow resistance apparatus, and of contract and grant study programs will be inputs to the development of more efficient acoustic liners and a program for predicting the acoustic performance of engine flow ducts.

W76-70036 **505-03-11**
Ames Research Center, Moffett Field, Calif.
BASIC NOISE RESEARCH
R. H. Petersen 415-965-5880
(505-06-23)

This research is being conducted to improve our understanding of the fundamentals of aerothermodynamic noise generation and propagation. The primary objectives are (1) to develop optimum subsonic and supersonic jet and core noise suppression methods that will provide at least a 60% reduction in currently achievable thrust loss penalty; (2) to develop improved and/or new methods of predicting noise generation; and (3) to predict the effect of a turbulent jet exhausting into an ambient mean flow. This research will involve both analytical and experimental studies of aerodynamic noise generation and suppression in propulsion systems. The research on noise generating mechanisms in hot, subsonic and supersonic jet flows will include detailed studies of the noise suppression effects of swirling flow on the noise producing mechanisms and the coupling mechanisms between core and combustion noise with the jet noise. A theoretical analysis of the turbulence structure and noise producing characteristics of swirling jets will be emphasized. Complete fields of mean velocity and all the turbulent correlations will be computed.

W76-70037 **505-03-11**
Lewis Research Center, Cleveland, Ohio.
BASIC NOISE RESEARCH
E. W. Conrad 216-433-4000
(505-90-03; 505-03-12)

This RTOP covers work directed toward understanding the basic principles and phenomena involved in the generation, propagation and suppression of turbomachinery, jet, jet-surface interaction, and core noise. The work combines in-house analytical and experimental studies with a number of university type grants and contracts to form a coordinated basic noise research program that is structured to permit aeroacoustic

specialists to carry out investigations of several years duration, if appropriate. The work is directed toward providing a broad base of understanding and knowledge of the various noise areas through fundamental, analytical and experimental studies. This foundation will provide a fundamental base for reducing aircraft propulsion generated noise with minimum weight, performance, and economic penalties.

W76-70038 **505-03-12**
Lewis Research Center, Cleveland, Ohio.
NOISE TECHNOLOGY
E. W. *Conrad* 216-433-4000
(505-03-11)

The objective is to provide data and a technology base directed toward improved understanding of noise generation mechanisms and improved correlation and prediction techniques for reducing aircraft propulsion noise with minimum weight, performance and economic penalties. Research is performed on fan, core and combustion noise generation and its suppression and shielding. Fan noise research will be conducted in the 20-inch model rig in W-2 as well as by contract. Several acoustic parameters (such as reduced fluctuating stator lift, reduction of mpt's in transonic and supersonic fans by means of shock swallowing and shockless rotor blades, reduced rotor stator interaction, and boundary layer bleed) will be evaluated. Core and combustion noise research will be conducted to determine internal and far field noise spectra. Jet noise generation and methods of shielding jet noise will be examined. Forward velocity effects on STOL and CTOL engine-over-the-wing configurations will be evaluated. New ideas for noise generation mechanisms, noise reduction, and noise measurement will be investigated, and improved correlation and prediction techniques will be established. Sonic and hybrid inlets and inlets with large area variations will be studied and evaluated experimentally to optimize noise reductions with regard to performance losses and operational limitations.

W76-70039 **505-03-12**
Ames Research Center, Moffett Field, Calif.
NOISE TECHNOLOGY
C. T. Snyder 415-965-5567
(505-10-31)

This RTOP covers acoustic research on axial flow fans with emphasis on those designed for V/STOL propulsion systems. Our objective is to achieve meaningful reductions in fan-stage source noise through improved aeroacoustic design and testing practices. The program proposed for FY-76 will continue to investigate and emphasize the control of fan inflow properties such as inlet turbulence and distortion as necessary to achieve lower fan-stage source noise. Programs already underway in FY -75 to more completely explain the lower fan tone noise levels in flight compared to static levels will continue. The investigation of and attainment of lower fan stage noise will also require new testing techniques some of which have already been used on small scale programs and will be extended to full scale systems.

W76-70040 **505-03-13**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION NOISE REDUCTION
R. R. Heldenfels 804-827-2042

The objective of this research is to develop and demonstrate advanced noise reduction technology for general aviation to meet proposed noise standards with minimum performance penalty and without degrading flight safety; and to develop a more complete understanding of propeller/propulsor noise mechanisms that will provide for aero/acoustic design prediction methodology for the evaluation and demonstration of noise reduction techniques. Theoretical and experimental studies will be undertaken in-house and under contract. Flight and wind-tunnel experiments will be undertaken with a specially instrumented propeller in order to relate the noise radiation to fluctuating pressure measurements on the blade surface as part of a general theory of noise generation. Other experiments involve wind-tunnel tests of acoustically designed shrouded propulsors, performance designed propellers, and the documentation of the noise signatures of typical general aviation aircraft.

W76-70041 **505-03-21**
Lewis Research Center, Cleveland, Ohio.
NOISE FOOTPRINT PREDICTION
F. J. Montegani 216-433-4000

Based on theoretical and experimental knowledge of aircraft component source noise and noise propagation, noise prediction models are formulated for incorporation into the NASA aircraft noise prediction program being developed at Langley Research Center for noise footprint prediction. The specific aircraft noise areas of major technical effort are: fan/compressor, turbine, jet, flap, combustion, duct acoustics, and shielding/reflection. The noise prediction models are formally documented as NASA publications. Those research areas critical to the improvement of noise prediction are identified and specific research programs to obtain the improvements are suggested. The work is structured to permit convenient validation, improvement and updating of the prediction models as additional information is developed.

W76-70042 **505-03-21**
Langley Research Center, Langley Station, Va.
NOISE FOOTPRINT PREDICTION
R. R. Heldenfels 804-827-2042

The objective of this work is to develop an verify an integrated, state-of-the-art aircraft noise prediction program (ANOPP). A wide range of activities is being undertaken to assure that the most advanced, yet widely accepted, prediction methods are implemented. The areas of flyover noise measurement-noise data reduction techniques, airport and aircraft operating procedures, data base maintenance, component noise sources and source noise modeling, shielding, reflection, propagation, and computer sciences will be continuously reviewed and updated.

W76-70043 **505-03-31**
Langley Research Center, Langley Station, Va.
EXHAUST EMISSION POLLUTION RESEARCH
E. S. Love 804-827-2893
(505-03-32)

The objective of this work is to experimentally and analytically investigate the effect of combustion kinetics, temperature, pressure, and mixing on the production of gaseous and particulate pollutants in hydrocarbon-air combustion systems. The results of these studies will be used to assemble more reliable chemical kinetic schemes for describing the combustion of hydrocarbon fuels such as jet fuels and predicting pollutant formation (NOx and soot) in gas turbine combustors. These studies will be made using laboratory flame burners, a chemical kinetic shock tube, and a jet stirred combustor. This study will also investigate the effect of hydrocarbon fuel structure and composition on the combustion of hydrocarbon fuels and associated flame radiation and nitric oxide levels. Empirical relationships between fuel properties and pollutant/radiation levels will be assembled.

W76-70044 **505-03-32**
Lewis Research Center, Cleveland, Ohio.
EXHAUST EMISSION POLLUTION REDUCTION
R. A. Rudey 216-433-4000
(743-34-21)

The objective is to develop, evaluate, and demonstrate the technology required to reduce modern gas turbine aircraft engine exhaust emission pollutants to levels complying with current and future environmental air quality standards with minimum adverse effects on performance, weight and complexity. Various techniques for reducing pollutants emissions are being investigated both in-house and under contract in full scale combustor rigs, combustor segment rigs, and basic flame-tube type rigs. Five major multi-phased contract efforts are being used to develop and demonstrate, in modern aircraft engines, advanced combustor concepts that are aimed at reducing the pollutant emissions to levels equal to or less than those established by the EPA for engines manufactured after 1979. These programs include candidate engines from all designated classes covered by the EPA standards for civil aviation aircraft. In-house and contract efforts to explore high pressure-high temperature advanced combustor designs, fundamental modeling and combustion pollutant formation studies, identification of odorants, and non-invasive measurement techniques are also being conducted.

W76-70045 **505-03-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GAS TURBINE ENGINE POLLUTION REDUCTION TECHNOLOGY
R. R. McDonald 213-354-6186

New (unconventional) combustor design concepts for application to aircraft gas turbines are being evaluated for their potential for providing significantly reduced pollutant emissions. Reducing oxides of nitrogen while maintaining efficient, clean combustion is emphasized. The central conceptual approach is to minimize NO formation rates by reducing flame temperature and by promoting of-stoichiometric burning. The overall objective for FY'76 is the demonstration of feasibility of implementing the H2-enrichment concept to provide for very lean combustion of H2-/JP fuel mixtures. Primary emphasis is placed on establishing an experimental burner configuration that demonstrates stable, high efficiency combustion with low pollutant emissions over a range of inlet air conditions typical of contemporary, high performance turbine engines. Providing that concept feasibility is demonstrated using bottled-H2, a second objective is to commence exploratory experiments on the feasibility of incorporating a partial-oxidation reaction zone to generate the required H2. A continuing objective is the establishment of design criteria for implementing the H2-enrichment concept in practical combustion systems for aircraft turbine engines.

W76-70046 **505-03-33**
Lewis Research Center, Cleveland, Ohio.
GENERAL AVIATION INTERNAL COMBUSTION ENGINE POLLUTION REDUCTION
E. E. Kempke 216-433-4000

The overall objective of this program is to establish and demonstrate the technology necessary to safely reduce general aviation intermittent combustion engine exhaust emissions to meet EPA 1979 standards and to reduce fuel consumption with minimum adverse effects on cost, weight, and reliability. With the advent of more restrictive standards on the pollutant emission of aircraft piston engines and the drive to conserve our natural resources, there is a need to determine and develop better ways of handling the diverse but related areas. A comprehensive program comprising contract work by the primary engine manufacturers as well as a Lewis Research Center in-house technology effort has been established. Work performed under contract to the engine manufacturers will be directed to establish near-term solutions while in-house work will concentrate on longer term solutions such as alternative engines and concepts requiring additional technology. The experimental investigation of the lean operating limits and engine performance with an on-board hydrogen generator which supplies hydrogen for injection into an engine to extend the flammability limits of the primary gasoline/air mixture will continue.

W76-70047 **505-03-41**
Flight Research Center, Edwards, Calif.
ATMOSPHERIC EMISSION INTERACTION TECHNOLOGY (MINI-SNIFFER)
Robert Reed 805-258-3311

The objective of this RTOP is to develop a small remote piloted sampling vehicle (Mini-Sniffer) capable of encountering and sensing both natural and man-made atmospheric contaminates and fine turbulence in the altitude range from 50,000 to 100,000 feet. Since the vehicle will fly at low expected speed it will provide precise positioning and maneuvering in segmented atmospheric pollution concentrations at these altitudes as well as defining the basic fine atmospheric turbulence characteristics at these altitudes. The Mini-Sniffer is the only stratospheric sampling platform that can gather both fine turbulence data in aircraft wakes as well as ambient atmospheric data (gust velocities less than 0.1 foot per second and wave lengths less than 200 feet) in horizontal and vertical surveys. The design target is to develop an inexpensive vehicle and an operational technique requiring only a one or two-man crew to operate in addition to radar and payload support personnel.

W76-70048 **505-03-42**
Ames Research Center, Moffett Field, Calif.
CV-990 AIRCRAFT SUPPORT OF LEWIS RESEARCH CENTER GLOBAL AIR SAMPLING PROGRAM (GASP)
D. R. Chapman 415-965-5065
(505-03-41)

This RTOP is to provide CV-990 aircraft (NASA 712) support of the Lewis Research Center Global Air Sampling Program (GASP). The LeRC Experimental equipment will be mounted and flown aboard the CV-990 for purposes of development and prototype testing of instrumentation to be installed on commercial airliners. The research program is under the cognizance of the Lewis Research Center (P. J. Perkins and G. M. Reck).

W76-70049 **505-04-11**
Lewis Research Center, Cleveland, Ohio.
INLET AND NOZZLE TECHNOLOGY
D. N. Bowditch 216-433-4000

Improved analytical and experimental design methodology for inlets and nozzles will be generated to achieve higher performance with increased propulsion system stability. These results will minimize future development effort and cost of advanced civil and military aircraft. Computer analysis programs for predicting both internal and external flows will be synthesized in-house and by contracts and grants. These programs will make it possible to analyze combined viscous and inviscid flows and, in some cases, three-dimensional flows. A matrix of inlets and nozzles will be tested for comparison with theory and to provide design trade information for optimization of aircraft configurations. The compatibility of the inlet and nozzle with the turbine engine and airframe will be investigated to develop inlet-engine-nozzle compatibility methodology. Experimental testing will take place in 10x10, 8x6, on the F106 aircraft and in a static thrust stand, CE 22.

W76-70050 **505-04-11**
Langley Research Center, Langley Station, Va.
INLETS AND NOZZLES
R. E. Bower 804-827-3285

Studies of locations of the engine power plant in various positions of the airframe will be conducted in order to achieve better integration with the airframe and to exploit any favorable jet interference effects which may enhance the wing lift performance efficiency, reduce drag or permit vectoring of the jet exhaust to improve performance and control of the aircraft. For the exhaust nozzle, investigations will be made to determine a means of improving the internal and external performance of both uninstalled and installed nozzles and to explore the integration procedures for incorporating the exhaust system into the fuselage or pods. General experimental and theoretical research studies will be conducted to improve the understanding of the flow phenomena associated with inlet boattail/jet/empennage interference. Experimental research on axi and non-axisymmetric nacelles and inlets will be conducted for correlation with analytical results and design procedures will be developed from this information.

W76-70051 **505-04-11**
Ames Research Center, Moffett Field, Calif.
INLET TECHNOLOGY
Richard H. Petersen 415-965-6116
(505-06-15; 505-06-11)

The objectives of this research are to provide information in the design and operation of efficient air induction systems for subsonic and supersonic aircraft and to apply this technology to other internal flow problems of importance. The specific areas receiving attention are: (1) a general understanding of the basic problems encountered in inlet flows (externally produced flow fields at the inlet entrance, boundary layer growth and interaction with shockwaves, boundary layer separation, mass exchange at the boundaries, etc.) and development of new mathematical design procedures; (2) detailed studies of two general classes of inlets, two dimensional and axisymmetric, that are readily amenable to mathematical modeling; (3) continuous updating of available computer programs derived to aid in inlet design; (4) flow distortion and unsteadiness at the engine face and correlation of these phenomena with loss in engine stall margin; and (5) application

of inlet technology to the development of high performance and diffusers for gas dynamic lasers.

W76-70052 **505-04-21**
Lewis Research Center, Cleveland, Ohio.
FAN AND COMPRESSOR TECHNOLOGY
M. J. Hartmann 216-433-4000
(511-51-01)

Approaches to improve efficiency, operating range, distortion tolerance, durability and reliability and to reduce weight, volume, and cost of the wide variety of fans and compressors required for advanced propulsion systems will be investigated. Analytical methods to improve accuracy of performance prediction to reduce the time, cost and risk of incorporating advanced fans and compressors into future engine development programs will be developed and compared to experimental data obtained in advanced single and multistage compressors. Both in-house and contract efforts are required. The major program thrusts are: (1) extend fan stage pressure ratio; (2) improve fan performance with low noise design and devices; (3) improve distortion performance; (4) evolve design/analytical/evaluation method; (5) improve performance retention; (6) determine matching requirements of high pressure stages; (7) extend core stage pressure ratio; and (8) improve performance of small centrifugal compressors.

W76-70053 **505-04-22**
Lewis Research Center, Cleveland, Ohio.
TURBINE TECHNOLOGY
D. Poferl 216-433-4000

The turbine program includes research on turbine aerodynamics, turbine cooling, and turbine life. Each of these areas are inter-related, and it is not practical to conduct research in one area without considering how the other areas will be affected. Advanced cooling schemes for very high gas temperature operation will require increased use of film cooling. The effects of this and other types of cooling air discharge are being investigated from the standpoints of heat transfer, aerodynamics, and blade life. Heat transfer, fluid flow, aerodynamics, and life investigations are underway for a variety of convection and film configurations for turbine sizes ranging from those for helicopter engines to high spool turbines for turbofan engines. Fundamental heat transfer investigations on film cooling are also continuing. Turbine cooling problems become much more severe at the very high heat fluxes that are encountered with turbine inlet temperatures in excess of 3000 F, and high gas pressures encountered with compressor pressure ratios in the range from 30 to 40. Design and fabrication of a turbine rig to investigate the heat transfer and structural problems encountered with these high temperature, high pressure turbines is being accomplished using Coff funds. In addition, investigations are being made on multi-stage turbines with work factors from 3 to 5 for application to high bypass ratio lift or cruise engines.

W76-70054 **505-04-23**
Lewis Research Center, Cleveland, Ohio.
PROPULSION INSTRUMENTATION
N. C. Wenger 216-433-4000

Present effort in propulsion research are often limited by the inability to make rapid and precise measurements of the parameters of interest. Rapid advances in propulsion technology have in many cases pushed conventional instrumentation techniques to their limits. Further work on improving conventional instrumentation and measurement techniques will probably result in only incremental improvements. The objective of this RTOP is to expand the instrumentation technology base and to explore new concepts that have the potential for significantly advancing present measurement capabilities. Particular emphasis will be placed on six critical areas that have been identified as serious impediments to full scale engine and component testing. They are: (1) turbine blade temperature measurement; (2) gas temperature measurement; (3) gas flow measurement; (4) blade tip clearance measurement; (5) blade flutter measurement; and (6) rotary instrumentation systems. New and improved measurement concepts and techniques in each of the six areas will be explored with each study culminating in an experimental demonstration of prototype instrument or system.

W76-70055 **505-04-31**
Lewis Research Center, Cleveland, Ohio.
COMBUSTION AND AUGMENTATION SYSTEMS TECHNOLOGY
R. A. Rudey 216-433-4000
(505-03-32)

The objective is to establish the technology necessary for combustors and augmentors to achieve high performance and good durability at operating conditions typical of advanced commercial and military gas turbine engines. A swirl-can combustor is being developed for use in the high pressure facility (HPF) both as a heat source combustor for the turbine rig and also as a research combustor. A variety of new combustor concepts will be investigated; first in a sector rig at low pressure, then further refined in design and tested as full annular designs in ECRL-1 at pressures up to 120 psi, and finally tested in HPF at pressures up to 580 psia. This effort will be supported by research in liner film-cooling, jet penetration and mixing, fuel injection, vaporization and premixing, premixed fuel autoignition and various diffuser and cold flow model tests. Several designs of small combustors of the reverse flow and axial flow types will be designed and tested for performance and emission characteristics. An augmentor program will study ways of improving augmentor performance of turbofan engines by investigating a variety of new design approaches.

W76-70056 **505-04-41**
Lewis Research Center, Cleveland, Ohio.
DRIVE SYSTEM MECHANICAL COMPONENTS TECHNOLOGY
W. J. Anderson 216-433-4000
(506-16-22)

The objectives of this work are to advance the technology for bearings, shaft seals, gas path seals, gears, shafts, lubricants, lubrication systems and mechanical power transmissions to achieve increased effectiveness, life, reliability, efficiency, and low weight in the high temperature, high pressure, and high speed environments of turbofan and turbopropellor engines, and mechanical power transmission systems. Basic materials development, design theory, lubrication techniques, analysis and experimentation will be performed for extreme conditions with lubricants, lubrication systems, bearings, seals and gears of advanced aircraft turbojet and turbopropellor engines to achieve efficient performance, reliability and extended life. Analytical techniques for balancing, determining and controlling the dynamic behavior of shafts and rotors will be developed and corroborated experimentally to provide better design tools for high speed turbomachinery, shafting and transmissions. New transmission concepts will be developed.

W76-70057 **505-04-51**
Lewis Research Center, Cleveland, Ohio.
FUELS TECHNOLOGY
R. A. Rudey 216-433-4000

The objectives are to determine the properties of future aviation turbine fuels derived from non-petroleum sources such as shale and coal, to acquire sufficient quantities of these fuels for performing research tests, to determine the effects of these fuels on the performance and durability of jet engine components and materials, and to evolve the necessary technology that is required to use these fuels in jet aircraft engines. Laboratory research to synthesize and characterize candidate aviation turbine fuels from coal and shale oil crudes will be conducted both in-house and under contract. Feasibility studies will be performed under contract to determine available sources of shale oil and to determine pilot plant capabilities required to produce sufficient jet fuel from shale oil to perform full-scale turbine engine components tests by FY 1979. Subsequent feasibility studies will be performed under contract to obtain similar information on jet fuel derived from coal. Combustor tests will be conducted with hydrocarbon blends that simulate the anticipated range of properties of synthetic fuels with broadened specifications. Subsequent combustor, fuel system, and full-scale engine research

will be conducted as various candidate synfuels become available. NASA-Lewis fuels technology effort will be coordinated with complementary activities being performed by the Air Force Aero-Propulsion Laboratory (APL).

W76-70058 **505-05-11**
Lewis Research Center, Cleveland, Ohio.
DYNAMIC BEHAVIOR AND CONTROL
D. I. Drain 216-433-4000

The objective is to improve the understanding of and prediction of propulsion system dynamic behavior so that the system can be controlled at maximum performance. Furthermore, the control of the system must be able to accommodate sudden and unexpected disturbances safely and reliably. The approach is to apply the methods of dynamic analysis and simulation to establish the characteristics of airbreathing propulsion systems. Control theories and concepts will be developed and applied to achieve improved performance and operation of the system. Special control hardware, such as servos, instruments, and actuators, will be developed as required. Experiments with components and complete systems will be performed to validate the methods and concepts developed for improved propulsion system control.

W76-70059 **505-05-11**
Flight Research Center, Edwards, Calif.
DYNAMIC BEHAVIOR AND CONTROL TECHNOLOGY
Weneth D. Painter 805-258-3311

The objective of this effort is to flight test an integrated propulsion control system (IPCS) on an F-111E airplane. The IPCS program objectives are to: (1) demonstrate the control of a state-of-the-art propulsion system using a digital computer and associated interface equipment; (2) evaluate the improvement in steady-state and transient propulsion system performance due to IPCS; and (3) evaluate the changes in compatibility between the engine and inlet, (stall margin change).

W76-70060 **505-05-21**
Lewis Research Center, Cleveland, Ohio.
ENGINE TECHNOLOGY
Ross Willoh 216-433-4000

The objective of this program is to provide an improved technology base for future engine system development. Experimental and analytical efforts are undertaken to acquire understanding and to improve the technology base for the various technical diciplines associated with the detailed behavior, both dynamic and steady state, of the complete engine system. The objectives will be accomplished through research sub-programs on advanced subsonic and supersonic civil and military engines. Particular emphasis will be placed on seeking understanding and solutions for the dynamic interaction problems encountered when engine components are combined to form an engine system. The sub-program will include investigations in areas such as Aeromechanical instability, fan and compressor performance, inlet distortion, engine dynamics and controls, and the performance of various components. The overall program is primarily concerned with significant technical areas where large descrepancies exist between theory and actual performance. Engines currently in the program include J-85-13, J85-21, TF-30 and the F-100.

W76-70061 **505-05-22**
Lewis Research Center, Cleveland, Ohio.
POWERED LIFT ENGINE TECHNOLOGY
Carl C. Ciepluch 216-433-4000
(738-01-01; 505-02-43)

The objective of this RTOP is to advance the technology related to understanding the interactions between the engine, nacelle and airplane for powered-life propulsion systems. The particular interactions to be studied include the nacelle, including inlet and exhaust nozzle, reverse thrust configuration and the wing/flap configuration. Both aerodynamic and acoustic interactions will be studied. In addition, technology will be developed for fans and ejectors suitable for thrusters for VTOL aircraft systems. The desired technology will be brought forth through analytical model development and test programs using models, components engines and engine, nacelle and wing systems as required.

W76-70062 **505-05-24**
Lewis Research Center, Cleveland, Ohio.
LIFT/CRUISE FAN PROPULSION SUPPORT
A. G. Powers 216-433-4000
(514-54-02)

This RTOP is to cover the continuing lift/cruise fan engine contract effort and LeRC technical involvement in support of the jointly sponsored preliminary studies of the L/C fan technology aircraft. The support includes: (1) extension of the present engine contract to further refine the preliminary design and, in particular, to evaluate problem areas; and (2) LeRC technology studies of lift fans and turbines.

W76-70063 **505-05-41**
Langley Research Center, Langley Station, Va.
BASIC HYPERSONIC PROPULSION
R. E. Bower 804-827-3285

This research program is directed at the development of concepts for airframe-integrated scramjet engines and the associated basic technology. Component development investigations are conducted inhouse at LRC on inlet, combustor, and nozzle designs applying to flight Mach numbers from 3 to 10. These results are incorporated in complete sub-scale hot engine models on which experiments are conducted at Mach 7 in the LRC Scramjet Facility and at Mach 4 in the AEDC APTU Facility. More basic research is conducted on H2 fuel injection, mixing, and combustion in both 2-D and axisymmetric flow fields for both wall and stream injection in order to advance prediction and design techniques. Inhouse program is augmented in some areas by R and D grants and contracts. Design studies on flight weight, fuel-cooled engine structures and systems are conducted in parallel with the aerothermal program. Program generally is focused on definition of experimental scramjet engine for flight tests on research airplane. Studies of low speed thrust devices are conducted primarily inhouse for the purpose of synthesizing complete propulsion system concepts for hypersonic vehicles.

W76-70064 **505-05-41**
Ames Research Center, Moffett Field, Calif.
HYPERSONIC PROPULSION RESEARCH
Richard H. Petersen 415-965-5876
(505-04-11; 505-06-15)

This is the final effort of the investigation of advanced hypersonic inlet flow fields to develop the methodology for predicting the internal flow (i.e., shock-wave boundary layer interactions, etc.) in hypersonic inlet systems needed for efficient and stable scramjet engine system design. Experimental and analytical studies of hypersonic inlet flows are to be concluded in which the effects of coupling between the inlet, fuel injection system and combustor are to be evaluated, and in which fuel injection and combustor pressure rise are simulated so that the effects of these factors on mixing flow distortion and inlet performance can be determined. A body of detailed internal flow data urgently needed to enable assessments of analytical methods will be obtained and reported. The study will be concluded by mid FY-76.

W76-70065 **505-05-51**
Lewis Research Center, Cleveland, Ohio.
ADVANCED SYSTEM CONCEPTS
R. J. Weber 216-433-4000

In-house and contracted studies will be performed of engine cycles, complete propulsion systems, and integrated engine/airframe combinations applied to representative airplane missions. The object of the studies is to determine desirable engine component and system design characteristics for future aircraft and to identify technology deficiencies and profitable areas for research. The studies will explore the opportunities for satisfying environmental and natural resource constraints and their related impact on propulsion system selection and aircraft performance. Representative topics include concepts for reducing fuel consumption of subsonic transports and variable-cycle engines for supersonic military aircraft. Supporting efforts will be included to develop new or improved techniques for estimating the cycle performance, weight, and other characteristics of advanced engine concepts.

W76-70066 **505-05-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HYDROGEN ENRICHMENT FOR AIRCRAFT PISTON ENGINES
R. R. McDonald 213-354-6186

Analytical and experimental investigations of the potential for hydrogen-enriched fuels achieving significant reductions in fuel consumption while simultaneously reducing pollutant emissions in conventional aircraft piston engines will be conducted. Analytical representations of both supercharged and normally aspirated engine systems including all components required for on-board hydrogen generation will be formalized as a means for estimating changes in aircraft system efficiency and aircraft operating envelope. The performance improvements indicated by these estimates will be verified in a series of laboratory experiments on a selected aircraft engine type utilizing currently available hydrogen generators as separate laboratory components. The performance of these generators will be verified with aircraft type fuels prior to integration into the laboratory systems. The estimated impacts on aircraft performance will be verified by flight testing the selected engine type in an aircraft which normally uses that engine (as unmodified). Aircraft/engine modifications will be limited to those minimum changes commensurate with a definitive experiment, an integral with engine hydrogen generator, and aircraft safety. A cooperative effort between NASA and cost-sharing Industrial Contractors is contemplated.

W76-70067 **505-06-11**
Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL AERODYNAMICS
Leonard Roberts 415-965-5859
(505-06-15; 505-04-11)

The objective is to develop analytical and numerical procedures which can be used for the study of complex aerodynamic flow fields at subsonic, transonic and supersonic flight speeds. The procedures will apply to two and three-dimensional configurations and will include consideration of viscous effects. Flow field studies in the subsonic, transonic and supersonic speed regime will continue covering flows, with and without separation, using finite difference, relaxation technique, and integral method solutions. Under this RTOP theoretical methods also will be developed to produce the flow fields about highlift wings and complete configurations at subsonic speeds. Computer codes will be written for two- and three-dimensional multi-element wings including viscous interaction effects. The theoretical programs will be supported by experiments under RTOP 505-06-31. The Ames Finite-Element Wing-Body Aerodynamics Computer Program will be modified to incorporate multiple bodies and vertical surfaces. Several of the computational methods that are under development or nearing completion will be tested and/or modified for use in the aircraft synthesis program (ACSYNT) being used to study various vehicle concepts. The computer codes will be compared against a more simplified existing code and implemented in ACSYNT. Emphasis will be given to correlating the results of these programs with experimental data and displaying the results on computer graphics equipment.

W76-70068 **505-06-11**
Langley Research Center, Langley Station, Va.
COMPUTATIONAL AERODYNAMICS
R. E. Bower 804-827-3285
(505-06-14; 505-06-15)

The objective is to develop the capability to analytically predict complete aerodynamic characteristics of complex three-dimensional aircraft configurations, now obtainable only by extensive wind tunnel tests (constrained by Mach number and Reynolds number limitations, sting and wall interference effects) to a degree that preliminary design concepts can be evaluated and screened with reduced wind tunnel test time and cost. Analytical and numerical procedures will be developed for the prediction of pressure distributions, aerodynamic characteristics, flow fields, skin friction and heat transfer for inviscid, viscous and coupled inviscid-viscous flows with attached and separated boundary layers, detached lee side flows with vortex formation and other interactions. Both linear and nonlinear, exact and approximate flow equations will be applied as appropriate. Mathematical techniques required typically depend on the problem; however, finite-element, finite-difference relaxation, time-asymptotic, characteristics and integral methods are the most commonly used for solving nonlinear problems. Linear problems will generally be solved by the distribution of various types of singularities whose strengths are determined by the solution of a matrix equation. Several problems requiring large computer storage will be programmed for the STAR with particular emphasis on efficient solution algorithms.

W76-70069 **505-06-12**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF COMPUTATIONAL AERONAUTICAL CODES FOR ILLIAC
D. R. Chapman 415-965-5065
(505-06-13)

The overall objective is to develop efficient computer programs for solving fluid dynamics problems on the ILLIAC and large serial computers. A wide variety of fluid flows, steady and unsteady, inviscid and viscous, is to be simulated from low subsonic to hypersonic speeds for two- and three-dimensional configurations. Specific objectives are categorized under (1) numerical methods for partial differential equations, (2) CFD language software, (3) transonic flows, (4) supersonic flows, and (5) viscous flows. New numerical methods will be developed and analyzed with emphasis on those particularly suited for vector and parallel processing. The computer programs will be written in CFD language for processing on the ILLIAC, and with translators it will be possible to debug and execute the same programs on large serial computers, viz., the CDC 7600 and IBM 360 and 370 series.

W76-70070 **505-06-14**
Langley Research Center, Langley Station, Va.
THREE-DIMENSIONAL SEPARATED FLOWS
R. E. Bower 804-827-3285

The objectives are to perform basic research advancing the knowledge and prediction of aerodynamic phenomena involving various three-dimensional separated flows. Flows such as separation-induced vortex flows with reattachment on lifting surfaces and cross-flow separation on fuselage-type rotating bodies at high angles of attack are being studied. Theoretical and empirical methods are being developed to allow prediction of the aerodynamic characteristics and critical design loads of aircraft configurations to a degree that preliminary design concepts can be evaluated with reduced wind-tunnel test time and cost and the aerodynamic and structural trades can be more nearly optimized. The objectives also include studies of methods for optimizing and augmenting the separation-induced vortex lift for applications related to improved maneuver lift. In-house experimental and analytical studies augmented by additional studies performed under contracts and grants will be utilized to accomplish the objectives. The development of theoretical methods for lifting surfaces will utilize finite element techniques and the edge suction analogy method. The body cross-flow research will involve wind-tunnel studies of rotating bodies and the development of semi-empirical prediction methods based on two-dimensional noncircular cylinder data. Favorable component interference and powered augmentation methods will be used to improve the vortex-induced maneuver lift.

W76-70071 **505-06-15**
Ames Research Center, Moffett Field, Calif.
TURBULENT BOUNDARY LAYERS
Richard H. Petersen 415-965-6116
(505-06-11; 505-04-11)

The objective is to conduct analytical and experimental investigations of turbulent boundary layer flows under conditions where our present understanding of such flows is inadequate. These conditions include (1) flows over highly curved surfaces providing severe adverse pressure gradients (with and without bleed or mass injections), (2) flows in the immediate region of, and downstream of, shock-wave boundary-layer interactions, and (3) flows subject to variation of edge entropy. The flow may be attached or separated in any of the foregoing cases. The results will be utilized to obtain by mid FY-77 empirical turbulence

models for use in advanced computer programs for calculating complete flow fields including regions in which viscous effects play a predominate role.

W76-70072 **505-06-15**
Langley Research Center, Langley Station, Va.
TURBULENT BOUNDARY LAYERS
R. E. Bower 804-827-3285
(505-06-11)

The objective is to research to significantly improve our ability to predict the behavior of general turbulent shear flows including turbulent boundary layers and free mixing flows for aeronautical design purposes. Theoretical and experimental research on turbulent boundary layers, free mixing layers, and recirculating flows including effects of compressibility, pressure gradients, mass and heat transfer and three dimensional flows on turbulence modeling. Development of physical models of turbulent shear, structure of turbulent flows, and investigations into the concepts of controlling turbulence by introducing acoustic energy into the flow or by modifying boundary conditions. A coordinated theoretical and experimental program in which theoretical turbulence models are postulated based on the physics of the situation, with inputs from carefully conducted experiments which measure (1) surface shear and heat transfer, and (2) detailed structure of turbulent flows obtained by standard techniques and by means of hot wires, lasers and other advanced measurement techniques. Detailed data and turbulence models are used to develop and verify several large numerical codes including computational methods for three-dimensional boundary layers, three-dimensional fluid mixing, and vortex and separated flows.

W76-70073 **505-06-16**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF ADVANCED FLEXSTAB PROGRAM
R. H. Petersen 415-965-5880
(505-02-21)

The aeroelastic deflections experienced by large aircraft both in steady state and maneuvering (perturbed) flight have a major impact upon performance, stability, control, and the internal loads arising from such deflections. A major objective of this research is to develop improved analytical methods and to incorporate such improvements in the FLEXSTAB system of computer programs for calculating stability and control of flexible aircraft. Both longitudinal and lateral-directional motions are included. Modifications are planned that will provide improved lateral-directional results, more complete loads information, effects of active controls, and improved representation of non-linear aerodynamics. As modifications are made, the FLEXSTAB program will be validated by comparing computed results with experimental measurements from both flight and wind tunnel tests.

W76-70074 **505-06-17**
Ames Research Center, Moffett Field, Calif.
EFFECTS OF AIRCRAFT FLOW FIELDS ON ELECTROMAGNETIC WAVE PROPAGATION
R. H. Petersen 415-965-5880
(505-02-21)

The object of the research is to predict electromagnetic wave distortion in the visible and infrared portions of the spectrum, resulting from propagation through an open port of an airplane turret. This program will consist of both theoretical and experimental research. Wind-tunnel tests simulating the various types of flow surrounding the turret will be conducted for the purpose of improving existing or new theory. The tests are also intended to provide a better understanding of the phenomena so that the distortion can be minimized. The tests will include a scale model of an actual flight system, and the results will be correlated with flight test data to be obtained by the Air Force Weapons Laboratory. A theoretical study of electromagnetic wave propagation through a turbulent medium will be performed.

W76-70075 **505-06-21**
Ames Research Center, Moffett Field, Calif.
NONSTEADY AERODYNAMICS
R. H. Petersen 415-965-5880

The principal objectives of this research are to obtain an improved understanding and definition of the unsteady aerodynamic pressures and forces associated with aircraft buffet as affected by aerodynamic and geometric parameters, to obtain an improved understanding of the reaction or coupling of the aircraft structure to the unsteady aerodynamics, to develop methods of predicting buffet intensity and wing rock, and to develop means of extending the buffet boundary. Wind tunnel tests, verified by selective flight tests, will be conducted to obtain unsteady loads, pressures and model response characteristics for conditions from buffet onset through maximum buffet and wing rock onset. Additional wind tunnel parameteric studies will be made to assess various approaches toward alleviation of buffet and wing rock.

W76-70076 **505-06-23**
Langley Research Center, Langley Station, Va.
AIRFRAME AERODYNAMIC NOISE
R. E. Bower 804-827-3285

Noise generating mechanisms and far field acoustic signatures will be investigated using scale models of complete aircraft and of individual components. Methods for measuring airframe noise from models will be developed. The aerodynamic integrity of models being tested will be assured. Effort will be made to correlate flow field characteristics with noise. Work will be done in quiet flow facilities, wind tunnels, RPV's and the ANRL. Analytical methods will be derived for predicting the noise of individual components, component combinations, and complete configurations. Both empirically derived scaling laws and prediction methods based on the flow fields and geometry are under development. Trailing edge noise, as it relates to flap noise sources, is a topic which will receive special emphasis theoretically and experimentally. The development of instrumentation to measure acoustic signals in a flow and efforts to reduce the background noise in the V/STOL and FS wind tunnels will continue to improve the suitability of local facilities for acoustics related research.

W76-70077 **505-06-23**
Flight Research Center, Edwards, Calif.
AIRFRAME AERODYNAMIC NOISE
P. L. Lasagna 805-258-3311

The technical objective is to obtain an understanding of the fundamental mechanisms involved in the generation of noise from other than propulsive sources by the airflow over the airframe of an aircraft in flight, and to investigate methods whereby such noise could be effectively reduced without undue design penalties. In addition to theoretical studies, flight tests will be made using a series of airplanes to measure the ground noise of each airplane while descending along a landing approach path with the engines off. In so far as practical, the flight speed and configuration geometry of each airplane will be varied to ascertain the effects of flaps, slats, cavities, etc., on the noise spectrum and level. Tests have been done with an AeroCommander, JetStar and CV-990. Testing will be continued using the JetStar and CV-990.

W76-70078 **505-06-23**
Ames Research Center, Moffett Field, Calif.
AIRFRAME AERODYNAMIC NOISE
L. Roberts 415-965-5066
(505-03-11)

The objective of this RTOP is to provide the necessary data and to determine the design principles necessary to reduce airframe noise by 10 db in the next decade. As a first step in this process, the noise level and spectra from the major sources of airframes noise are being identified by performing extensive measurements in such large scale wind tunnels as the 40- by 80-foot wind tunnel and the 7- by 10-foot wind tunnel. Additional small scale testing on specific noise sources are being conducted in the 25- by 35-cm Acoustic Test Apparatus. Noise sources investigated include turbulent boundary layers, vortex systems and wakes, separated flows, landing gears, and high lift devices. Special diagnostic techniques are under development for discriminating the desired noise signal from the extraneous noise generated in the wind tunnel environment. A parallel theoretical effort for predicting the noise generated by solid bodies in an airstream is also underway. A better understanding of the fundamental mechanisms will be used to design incisive experiments which willl reduce aircraft noise to acceptable levels.

Noise reduction techniques will be vertified in a series of wind tunnel tests on models of existing aircraft and representations of future aircraft.

W76-70079 **505-06-24**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AIRFRAME NOISE
T. Vrebalovich 213-354-4530

The objective of this task is three-fold: (1) to identify the sources of aerodynamic sound due to the flow about aircraft component models; (2) to seek means of reducing this noise through geometrical adjustments not inconsistent with aircraft design requirements; and (3) to gain improved understanding of the physical mechanisms of noise production according to which (2) can be accomplished. These objectives are to be pursued through wind tunnel testing, and with the use of a special acoustic measurement system developed for this use.

W76-70080 **505-06-31**
Flight Research Center, Edwards, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
E. J. Saltzman 805-258-3311

The objective is to improve ability to predict the aerodynamic efficiency of vehicles which move through the atmosphere, also, to define how the efficiency of airfoils or complete vehicles is influenced by geometry, Reynolds number, surface roughness and texture, and free stream and local flow conditions. In addition, experimental research on turbulent boundary-layer phenomena will be conducted. The latter will include exploratory model studies of the use of wing sweep for boundary layer removal on a swept back-swept forward (diamond) wing combination to improve maneuverability at low and transonic speeds. Overall and incremental drag of powered and coasting vehicles will be defined by the accelerometer and/or dynamic analysis methods augmented by the stabilized glide and rate of sink methods. Airfoil performance will be defined by conventional pressure distribution techniques, boundary-layer rakes and trailing wake probes augmented by flow visualization where required. Pressure distribution techniques will also be used in assessing boattail and base drag and in studying means of reducing these components of drag. The compliant skin approach of reducing friction drag may also be assessed. Turbulent boundary-layer studies will utilize rakes.

W76-70081 **505-06-31**
Langley Research Center, Langley Station, Va.
AIRFOIL AERODYNAMICS
R. E. Bower 804-827-3285
(505-06-11; 505-10-11; 505-10-21)

The objective is to provide improved airfoils and multi-element high lift airfoils in four major sub-program areas: (1) advanced fixed-wing subsonic aircraft, (2) transonic executive and commercial transports and military aircraft, (3) advanced military and civil helicopters, and (4) special applications such as remote piloted vehicles (RPVs) and outsized cargo aircraft. Improvements are sought in the areas of basic aerodynamic performance, high lift and controls performance, and stall behavior. The work will be an intermix of both experiment and applied theory and will provide: (1) measurements of aerodynamic characteristics for selected configurations, (2) upgraded predictive aerodynamic analysis, (3) generation of airfoil design methodology for both subcritical and supercritical aerodynamic regimes, and (4) stimulation of new and unique design concepts, theoretical methods, and experiment techniques. Examples include new supercritical airfoils, General Aviation airfoils, leading and trailing edge high lift devices, and new rotorcraft blade sections. In addition, the work includes improvements in existing research facilities and techniques together with development of new and unique capabilities. These new capabilities are specifically directed toward achievement of high quality data at intermediate and very high Reynolds numbers, such as are obtainable through cryo-technology, at high angles of attack at transonic speeds, and at very high coefficients using multi-element airfoils at subsonic speeds.

W76-70082 **505-06-31**
Ames Research Center, Moffett Field, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
R. H. Petersen 415-965-5859
(505-06-11; 505-11-12)

This RTOP covers experimental investigations on airfoils, components, and configurations for advanced subsonic, transonic, and supersonic aircraft. The objectives of this research are: to provide basic aerodynamic information on advanced and/or improved airfoils, to improve the basic understanding of complicated flows, such as flow separation on both swept and unswept multi-element high-lift wing configurations, and to determine the potential configuration advantages of the oblique wing concept for use on various configurations. The airfoil data will be for use on both fixed and rotary-wing aircraft. This work will be primarily experimental and will be conducted in-house. Complementary theoretical investigations are covered in RTOP 505-06-11.

W76-70083 **505-06-32**
Langley Research Center, Langley Station, Va.
AIRFOIL DESIGN, ANALYSIS, AND HANDBOOK SERVICES FOR GENERAL AVIATION
P. K. Pierpont 804-827-2210

The objectives are to develop capabilities outside of government organizations to use advanced analytical methods and computer programs to (1) design and develop new low-speed airfoils for specific applications, and (2) to analyse and predict performance of new supercritical airfoils. In the face of strong international competition, such new expertise will provide needed additional direct technical support for the U. S. General Aviation industry. Specific applications will include light to medium weight single and twin engine private, sports, agricultural, and business aircraft - both propeller and jet types. The work will include: (1) dedication of contractors' existing computational facilities and aerodynamic analysis competence, (2) implementation of government supplied airfoil analysis and design programs and techniques, including tuning and optimization procedures where applicable, (3) demonstration of operational analysis and design capabilities, and (4) conduct of analysis and design services to both industry and government. The expertise to be developed is intended to expedite introduction of the advancements in both low speed and supercritical airfoils together with high lift technology into U. S. manufactured aircraft, and to permit NASA research scientists to focus on further advancements in analysis methods and numerical design techniques.

W76-70084 **505-06-41**
Langley Research Center, Langley Station, Va.
BOUNDARY LAYER STABILITY AND TRANSITION
R. E. Bower 804-827-3285

The objective is to identify and control sources of stream disturbances in supersonic/hypersonic wind tunnels, identify and eliminate dominant causes of transition in nozzle wall boundary layers, develop and test noise shield concepts to reduce and control test section noise levels, develop methods to predict effects of various disturbances on transition and on fully turbulent boundary layers and shear layers, and design and construct a 1/2-Meter Quiet Tunnel. The approach is to test and perfect settling chamber components, laminar flow nozzles and sound shield in a Mach 5, 5-inch exit diameter, Pilot Quiet Tunnel. Hot-wire and high response pressure transducers (or microphones) are used to determine disturbance sources, amplitudes, and scales. All phases of the work are being conducted under close consultation with Reshotko, Klebanoff, and other members of the NASA Transition Study Group. The 1/2-Meter Quiet Tunnel will be constructed in two phases as follows: Phase 1 is now underway and consists of modifying and mounting an existing heater case as a settling chamber plus the development and testing of optimum components such as turbulence screens, baffles, and acoustic silencers which have to be tailored to the specific installation. Phase 2 will be funded with C of F money and consists of the design and construction of a laminar flow nozzle and the design and fabrication of the test section, noise shield, and vacuum system.

W76-70085 **505-06-42**
Langley Research Center, Langley Station, Va.

TUNNEL AND SCALE EFFECTS IN TRANSONIC FLOW
R. E. Bower 804-827-3285

The technical objective is to provide the technology for improved transonic wind-tunnel test capability for experimental prediction of performance and flight characteristics of conceptual or new aircraft designs. In-house, contract and grant supported research utilizing both analytical and experimental approaches will be used to accomplish the objective with the efforts being concentrated in the following specific areas: (1) cryogenic wind-tunnel technology and studies in direct support of the Transonic Research Tunnel project, (2) research and development directed towards application of the superconducting magnetic balance and suspension system to the 1/3-meter cryogenic transonic wind tunnel, and (3) research on transonic tunnel walls designed to minimize interference and the development of improved wall interference correction methods.

W76-70086 **505-06-42**
Ames Research Center, Moffett Field, Calif.
TUNNEL AND SCALE EFFECTS IN TRANSONIC FLOW
R. H. Petersen 415-965-5850

The general objective of this research is to develop by FY-77, improved transonic wind tunnel test techniques in order to ensure reliable correspondence between viscosity-dependent data obtained from scale-model tests and that from full-scale flight tests. Tunnel wall constraints, flow quality and means for simulating higher Reynolds number flows will be investigated analytically and experimentally.

W76-70087 **505-06-43**
Langley Research Center, Langley Station, Va.
FLOW MEASUREMENT TECHNIQUES
R. E. Bower 804-827-3285

This effort will develop instrumentation technology to improve measurement techniques to satisfy present and future aeronautical testing requirements. The work is predominately an in-house effort with emphasis placed on research where successful results will provide measurement technology broadly applicable to aeronautical programs. Technology developed under this RTOP will be coordinated with more focused instrument development in other programs. Research to be pursued includes development of gas velocity measurement techniques, improvements in heat flux and thermal mapping measurements, aerodynamic load measurements, model attitude, and digital data acquisition techniques. These research tasks will be continually alined with present and projected aeronautical program measurement requirements.

W76-70088 **505-06-43**
Ames Research Center, Moffett Field, Calif.
FLOW MEASUREMENT TECHNIQUES
Richard H. Petersen 415-965-6116
(505-06-15; 505-06-31; 505-06-81)

A laser velocimeter system is being developed for obtaining mean velocities, turbulence intensities, and Reynolds stress components in both low and high speed flows. Further, a large scale (8 watt) portable laser velocimeter system is to be developed for measuring local velocities in the Ames 2- by 2-foot and 6- by 6-foot facilities. Measurements will continue to be made with the 4-watt laser velocimeter in the Ames 8 x 8 inch supersonic wind tunnel in the natural boundary layer on the tunnel wall and downstream of a shock-wave boundary-layer interaction, and compared with hot wire anemometer measurements. This effort to be completed by FY-77 will be coordinated with the analytical and experimental studies in the turbulent boundary layer task of RTOP 505-06-15. The work in the 2' x 2' wind tunnel will be coordinated with the effort (airfoil studies) in RTOP 505-06-31 and the 6'x6' wind tunnel measurements will be coordinated with the stall/spin RTOP-505-06-95.

W76-70089 **505-06-70**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NON-LINEAR WAVE INTERACTIONS IN FLUIDS
T. Vrebalovich 213-354-4530

The object of this RTOP is to develop a new theory of differential systems, and to apply it to achieving a systematic understanding of selected important equations of continuum mechanics. The methods being developed are especially applicable to coupled sets of nonlinear ordinary and partial differential equations, where results previously have been found by ad hoc methods. Examples are (1) invariance transformations, (2) general similarity solutions, (3) characteristics, (4) integral conservation theorems, (5) discovery of nonlinear superposition principles, and (6) variational principles. Of these, (3), (4), and (6) are of direct applicability in writing programs for numerical computation. (5) and (6) are the most active current areas of research in applied mathematics, and progress by close interaction of computer simulation studies and analytical techniques. The method is based on the modern calculus of exterior differential forms, and is especially appropriate for nonlinear equations such as occur in describing aerodynamics flows and in nonlinear wave propagation phenomena. The systematic structure of the theory also allows the use of computer symbolic analysis. The most recent work under this task has been (1) in the application to coupled sets of ordinary differential equations, in showing how Hamiltonian structures may always be found for these, and (2) in discovery of transformations generating multiple soliton solutions to nonlinear dispersive wave equations. Such equations occur not only in classical fluids, but in plasmas, solid-state devices, laser optics, and new superconducting computer elements. Work is in progress in applying the theory to the systematic discovery of conservation laws and variational principles. These are used in relaxation type computer calculations, and have previously been discovered only by ad hoc methods.

W76-70090 **505-06-71**
Langley Research Center, Langley Station, Va.
INSTITUTE FOR COMPUTER APPLICATIONS IN SCIENCE AND ENGINEERING (ICASE)
J. E. Duberg 804-827-2664

This RTOP provides for the continuing operation of the Institute for Computer Applications in Science and Engineering (ICASE) located at the Langley Research Center, Hampton, Virginia. The Institute brings together experts from universities and industrial establishments to perform research in applied mathematics and computer science in conjunction with Langley Research staff members. The major research areas include activities related to computational fluid dynamics, the efficient use of fourth generation computers, the development of numerical algorithms for scientific and engineering calculations, and large-scale engineering and scientific software systems. Additional research is carried out in a variety of areas also of interest to Langley Research Center. The Institute is operated under an agreement between the Langley Research Center and the Universities Space Research Association. This RTOP provides for a fee for the Association, salaries of a small permanent scientific staff, stipends for visiting university professors, post-doctoral fellowships, support for student assistants, and a small administrative staff. Other members of the Institute include NASA fellows and industry associates whose salaries are paid by their employers. The Langley Research Center provides office space and some administrative and technical support.

W76-70091 **505-06-72**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF COMPUTATIONAL TECHNIQUES
D. R. Chapman 415-965-5065
(505-06-12)

The objective is to invent new mathematical methods and to extend and improve existing methods for simulating on a computer various physical phenomena. Emphasis will be placed on the study of numerical methods rather than the solution of the physical problem although the latter is the ultimate objective. Various aspects of the mathematical procedure will be studied. Initially, the governing equations must be formulated in a coordinate system that is appropriate to the particular problem with its boundary and initial conditions. Then various mathematical methods will be analyzed for accuracy and efficiency using model equations. Promising methods will be tested and evaluated for simplified problems with known analytic solutions. Finally, the best method will be applied to the full equations governing the physical phenomenon.

W76-70092 **505-06-73**
Langley Research Center, Langley Station, Va.
APPLIED MATHEMATICS AND COMPUTER SCIENCE
J. E. Stitt 804-827-3745

This RTOP is for basic research in the disciplines of applied mathematics, numerical analysis, and computer science, with emphasis on the application of computers to aerospace problems. The objectives of this research are the development of mathematical and computer science theory and the development of more effective analytical and computational techniques for the solution of the types of aerospace research problems encountered at LaRC. In fiscal year 1976 the topics to be addressed are (1) approximation and estimation theory and techniques, (2) optimization theory and methods, (3) statistical methods for cluster analysis, (4) the theory and numerical solution of differential and algebraic systems, (5) interactive computer graphics, (6) computer aided symbolic and algebraic manipulation, and (7) programing languages and methology. Most of the work covered by this RTOP will be performed in-house. Some support contractor assistance is anticipated in the development of computer programs, comparative analyses, etc., and a number of grants or research contracts will be awarded in selected areas within the specialities of the Langley Researchers.

W76-70093 **505-06-91**
Flight Research Center, Edwards, Calif.
HANDLING QUALITIES - CRITERIA FOR HIGHLY AUGMENTED VEHICLES
H. A. Rediess 805-258-3311

The overall objective of this effort is to advance the fundamental knowledge of flight dynamics and to exploit this knowledge to develop methods for optimizing specific flight control or performance goals and to improve flight-test analysis techniques. Analytical studies, computer simulations and flight-tests are being performed both in-house and under research contracts and grants to meet this objective. The range of command responses of augmented aerospace vehicles that optimizes the pilot-vehicle performance for specific missions or a specific task within a mission will be investigated. The main emphasis will be to investigate criteria for desired command responses that are meaningful to the systems designer and not needlessly restrictive as to the system concept employed. Certain aspects of wake vortex encountering dynamics will be studied through theoretical analysis, simulation and flight tests to assess the hazard involved and the ability of alleviating the upset by use of an automatic control system.

W76-70094 **505-06-92**
Ames Research Center, Moffett Field, Calif.
HANDLING QUALITIES - TURBULENCE/FLEXIBILITY EFFECTS
H. P. Klein 415-965-5094

Aircraft and pilot responses during atmospheric turbulence encounters are prime factors in the design and operation of all aircraft. To develop the basis for improved methods for specifying acceptable aircraft behavior under these circumstances, work is underway to: (1) refine existing ride qualities criteria for application to future large military or civil aircraft where structural mode excitation may have a first-order effect on both ride and handling qualities, and on pilot/aircraft performance, and (2) develop improved displays, autopilot modes and pilot procedures for severe turbulence encounters with advanced short-haul transport aircraft. This work will be accomplished by means of analytical and piloted simulator studies, both in-house and under contract. Research related to objective (1) will be completed by both in-house and contract personnel on the VARD simulator. Objective (2) will be accomplished by means of a contract study on either the VARD or another suitable ARC motion simulator.

W76-70095 **505-06-93**
Langley Research Center, Langley Station, Va.
ADVANCED CONTROL APPLICATIONS
R. E. Bower 804-827-3285
(766-75-02; 742-73-01)

The objectives are to develop a broad base of technology in control systems which make available to the designer the ability to improve the handling qualities, ride qualities, and stability and control of various types of aircraft, to investigate and encourage the adoption of techniques allowing maximum utilization of these principles by incorporating these considerations in the early design stages of an aircraft, and to improve techniques of extracting aerodynamic data from flight tests, particularly at high angles of attack. The approach is to conduct analytical studies to investigate the applications of several aspects of modern control theory to aircraft dynamics and control system synthesis. These studies include methods of decoupling airplane responses to individual control inputs, the automatic stabilization and control of helicopters with external slung loads, analysis of automatic landing systems, and the syntheses of gust-alleviation systems. Simulation studies are used to investigate the effects of promising systems on pilot opinion and on handling qualities; conduct studies of gust-alleviation systems utilizing accelerometer or vane sensors and airplane control surfaces; complete flight tests of simulated STOL airplane with decoupled controls; conduct studies of automatic control system that will perform steep, curved approaches; conduct simulation studies of methods of stabilizing and controling helicopters with external sling loads; and continue analytical and experimental studies on extraction of aerodynamic parameters from flight data for various aircraft at moderate and high angles of attack.

W76-70096 **505-06-95**
Ames Research Center, Moffett Field, Calif.
VEHICLE DYNAMICS - STALL/SPIN/HIGH ALPHA CHARACTERISTICS
Richard H. Petersen 415-965-6396
(505-11-22)

The objective is to provide a basic understanding of the aerodynamic characteristics of aircraft at high angles of attack through the development of improved theoretical methods supported by static and dynamic wind tunnel tests. Ultimately, through the application of improved methods and test results new criteria can be established for designing vehicles capable of performing controlled maneuvers over an expanded angle-of-attack envelope. Theoretical methods for calculating static aerodynamic coefficients are being developed in-house and on contract. Experiments in several wind tunnels are being performed to study basic aerodynamic flow phenomena, especially, at high angles of attack. Investigations are in progress to evaluate various experimental methods for determining dynamic characteristics of aircraft and experimental capabilities are being upgraded for testing at high angles of attack and high Reynolds numbers, both for static and dynamic characteristics. Dynamic apparatus are being constructed to evaluate aerodynamic coefficients which are pertinent to all phases of high-maneuver flight from controlled motions to fully developed spins.

W76-70097 **505-06-95**
Langley Research Center, Langley Station, Va.
VEHICLE DYNAMICS - STALL/SPIN/HIGH-ALPHA CHARACTERISTICS
R. E. Bower 804-827-3285

The broad objective is to expand fundamental knowledge of the stall/spin characteristics of aircraft, and to determine the effects of these characteristics in terms of piloting the aircraft. Specific objectives are: (1) to investigate the fundamental nature of stall/spin including the development of methods for theoretical analysis, (2) to investigate use of control systems for automatic spin prevention, (3) to determine aerodynamic characteristics at high angles of attack, and (4) to determine characteristics which produce a spin-resistant airplane. The methods of approach include wind-tunnel force tests, theoretical analysis, piloted simulator tests, and dynamic model tests.

W76-70098 **505-07-11**
Ames Research Center, Moffett Field, Calif.
APPLICATION OF CONTROL AND GUIDANCE THEORY TO THE AUTOMATIC AND MANUAL CONTROL OF FUTURE STOL AND VTOL AIRCRAFT
C. Thomas Snyder 415-965-5567
(513-53-03; 513-54-01)

The purpose of this research is to extend and apply advanced

linear and nonlinear modern control theory techniques to the guidance and control of STOL and VTOL aircraft. Two major efforts are involved: develop methodology and algorithms for generating fuel, time and noise optimal trajectories of STOL and VTOL aircraft operating in an advanced air traffic control environment; verify the guidance algorithms through an experimental flight program on the augmentor wing jet STOL aircraft and the tilt rotor research aircraft; develop and evaluate, with the assistance and participation of the FAA, a candidate 4D RNAV system in a real time terminal area simulation, and use the algorithms to establish optimum fuel conservation operations for in-service aircraft over the entire mission and identify airborne and ground systems required for implementation. This technique can be used for both STOL and CTOL operations. The second effort is to design a Full Flight Envelope Autopilot which uses a digital computer and the basic nonlinear aircraft force and moment equations to calculate open loop and corrective closed loop control sequences which smooth, follow and regulate general ATC trajectory commands, verify system performance by an experimental flight program using the STOLAND system on the augmentor wing jet STOL aircraft, and apply FFEAP design technique to tilt rotor aircraft.

W76-70099 **505-07-12**
Langley Research Center, Langley Station, Va.
JOINT UNIVERSITY PROGRAM ON AIR TRANSPORTATION SYSTEMS
J. E. Stitt 804-827-3745
(513-52-01; 513-50-51; 512-51-02)

The primary objective of this effort is to foster development of a university research capability across the disciplines that involve the avionics and flight control systems of aircraft and their interaction with the air traffic and airport operating environments. A secondary objective is to encourage university interest in inter-disciplinary education that will provide engineers and scientists capable of attacking the system problems involved in these areas of air transportation. Efforts to further improve communications and interactions between the schools, and to foster initiation of complementary projects will include joint quarterly meetings of the principal investigators, the production and exchange of video recordings of technical lectures, and the extension of the contract between Litchford Systems, Inc., and the universities. NASA, FAA, industrial and aircraft user-operating organizations will participate in briefings for program coordination.

W76-70100 **505-07-13**
Langley Research Center, Langley Station, Va.
DEVELOPMENT OF THEORETICS IN DIGITAL CONTROL
J. E. Stitt 804-827-3745
(512-53-01; 512-51-02)

The development of low cost flight computers of ever increasing speed, capacity, and reliability in recent years has provided a potential for more effective and easier implementation of flight control law mathematics than has been the case for the continuous time or analog systems of the past. Early applications of digital flight computers to control systems have in many cases employed rudementary and intuitive concepts for control law development and implementation. This situation existed because a theoretical background of design techniques for discrete time feedback systems and failure management has not been developed to the extent that such material exists for the continuous time systems used in the past. The purpose of this RTOP is to provide for theoretical researches to study and develop needed design techniques and operational concepts for discrete time systems to insure more efficient and effective use of digital computing systems for flight control. Experience and studies in the more applied programs such as ASA, TCV and the F8 DFWB program will serve to highlight problems of significance to which attention will be given. In turn the theoretical treatments in this RTOP will serve to advance concepts for possible proof of concept exploration in these more experimentally oriented programs. Areas to be given attention in this RTOP during the next year will include pattern recognition theory as applied to learning control concepts, the control of nonlinear plants through improved adaptive means, the integration of flight control functions, the improvement of energy management concepts, and the optimum design of multimode control software.

W76-70101 **505-07-21**
Flight Research Center, Edwards, Calif.
GENERAL AVIATION FLIGHT CONTROL SYSTEM AND DISPLAYS
Shu W. Gee 805-258-3311
(505-10-13)

This program is a coordinated effort to provide avionic system technology, development and criteria that will continue the improvements in safety and utility of all aircraft, particularly general aviation type aircraft. Various new concepts in flight control, navigation, and display systems are being investigated through the use of simulators and flight vehicles that will reduce the pilots workload and enhance his performance by applying human factors engineering to system design. Emphasis will be on low cost designs for general aviation.

W76-70102 **505-07-22**
Langley Research Center, Langley Station, Va.
AVIONICS ANTENNA TECHNOLOGY
J. E. Stitt 804-827-3745
(512-52-02; 505-07-12)

The objective of this RTOP is to develop low cost antenna technology for avionics systems that will be added to the existing aircraft. This includes the development of low profile antennas that can be added on with a minimum of structural penetration, and the determination of optimum locations of antennas using computer aided design techniques. The approach to be used is to expand previous work on printed microstrip and other low profile antennas to produce practical antenna elements and arrays with the polarization patterns and gain required; extend present computer programs and analysis to allow treatment of GA aircraft; and to conduct computerized siting studies along with extensive measurements using scale model aircraft. The results expected include prototype antenna hardware and drawings, a documented siting and antenna type study for programs such as MLS, and possible flight testing of antennas on selected aircraft.

W76-70103 **505-07-24**
Wallops Station, Wallops Island, Va.
NON-COOPERATIVE PILOT WARNING SYSTEM
L. C. Parker 804-824-3411
(505-10-14)

To determine the feasibility of a low-cost computer-aided radar system for automatic mid-air collision warnings on a noncooperative basis to all aircraft equipped with only standard NAV-COM systems in an uncontrolled air traffic terminal area. Studies will be performed to define the uncontrolled air traffic parameters, mid-air collision dynamics, systems approaches for detecting collision situations in this environment and for providing warnings to pilots involved. The feasibility of a system to provide pilot warnings and to prevent mid-air collisions in the uncontrolled terminal airspace will be evaluated analytically and demonstrated using existing and experimental breadboard systems.

W76-70104 **505-07-31**
Langley Research Center, Langley Station, Va.
HIGHLY RELIABLE CIVIL AIRCRAFT COMPUTER TECHNOLOGY
J. E. Stitt 804-827-3745
(513-52-01; 512-53-01; 505-07-41)

Detail logic design of two advanced fault-tolerant computer system architectural concepts will be initiated. Formal proofs of design will be developed to prove correct fault recovery strategies. Procedures for obtaining data inputs for reliability assessment tools will be developed, and reliability assessments will be performed for the fault-tolerant computer system designs. Software faults and their impact on systems reliability will be investigated. In-house investigations of off-the-shelf computer systems will be performed to gather data for determining that reliability improvements and fault-tolerance are reliable.

W76-70105 **505-07-41**
Langley Research Center, Langley Station, Va.

AUTOMATED VTOL AVIONICS
J. E. Stitt 804-827-3745
(513-53-04; 513-54-02; 505-10-23)

This effort will derive and validate the advanced avionics technology required for reliable, all-weather operations of a viable short-haul transportation system in the 1980's. Technology developed under this RTOP along with coordinated efforts in aeronautics (505-10-23) and operating systems (513-54-02) are the major elements of an integrated LRC program with the ultimate goal to develop and demonstrate operational capability of VTOL as a short-haul transportation system. The navigation, guidance, and control requirements for enroute, terminal area, and approach and landing of VTOL aircraft will be determined with emphasis on automatic operations. New technology will be used to develop low cost and reliable radio-inertial navigation systems, displays, sensors, and to evaluate hemispheric coverage landing guidance systems. Designs of functionally integrated systems will be implemented in prototype hardware and flight tests will be conducted to evaluate and demonstrate systems performance. VTOL guidance, navigation, and control requirements, and concepts will be investigated by extending previous analytical studies, simulation, and flight experiments to include automatic flight and landing operations.

W76-70106 **505-08-10**
Flight Research Center, Edwards, Calif.
KNOWLEDGE OF ATMOSPHERIC PROCESSES
L. J. Ehernberger 805-258-3311
(516-51-02)

The objective of this work is the definition of the atmospheric conditions in which turbulence, temperature transients, potential pressure altimetry problems and excessive wind shears occur. The major emphasis is the atmospheric environment of supersonic aircraft. Development and acquisition of sensors needed to measure these phenomena are also included. Results of this work will be applicable to aircraft systems design as well as flight operations routing and scheduling. Observations of these phenomena are obtained from instrumented aircraft test flights. The associated meteorological conditions are analyzed and studied both in-house and on contract.

W76-70107 **505-08-10**
Marshall Space Flight Center, Huntsville, Ala.
KNOWLEDGE OF ATMOSPHERIC PROCESSES
G. H. Fichtl 205-453-0875

The objectives of this RTOP are: (1) the definition, modelling, and simulation of steadystate wind and turbulence environments for aircraft accident investigation and the identification of aircraft operating hazards; (2) the modification of airports; and (3) the development of techniques and procedures whereby the knowledge of the natural environment can be better utilized for the safe operation of aeronautical systems. The objectives shall be accomplished by: (1) the development of models of atmospheric boundary layer flow properties; (2) the development of probabilistic models of turbulence and the conditions which lead to turbulence; and (3) performing analytical and laboratory tests relative to the life cycle of fog. To accomplish these objectives, the following tasks will be performed: (1) Task-01: Induced wind environments at airports. (2) Task-02: Natural environment reconstruction for aircraft accident and operating hazard investigation. (3) Task-03: Free atmospheric perturbations and turbulence (CAT). (4) Task-04: Fog modification. (5) Task-05: Laser Doppler acquisition of gust correlation matrix data.

W76-70108 **505-08-20**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION AIRCRAFT OPERATING EXPERIENCES
R. E. Bower 804-827-3285

Statistical data on the operational experiences of general aviation airplanes are being collected and analyzed. Data are obtained by NASA VG and VGH flight recorders from airplanes involved in representative operations of general aviation aircraft usage. Data collected provide information on the ground and flight loads, on the airspeed and altitude operating practices, and on the aircraft's operating environment. The information obtained provides: (1) a continuous basis for comparing actual airplane loadings with design loadings, and, thereby, a check on the adequacy of design criteria; (2) a means of detecting unanticipated operational practices; and (3) provides a bank of data useful in the design and development of airworthiness requirements for new types of airplanes.

W76-70109 **505-08-21**
Lyndon B. Johnson Space Center, Houston, Tex.
AIRCRAFT OPERATIONS AND SAFETY R&T
R. W. Bricker 713-483-3166

The effort defined in this RTOP consists of a continuation of work originally started in FY-73 and continued through FY-75. It also provides for funding the additional task of technical and operations support by DTMO (Development Testing and Missions Operations). This task will cover the refurbishment, instrumentation of the 737 fuselage, and conducting of the testing of materials for flammability.

W76-70110 **505-08-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AVIATION SAFETY R&T -FIRE TECHNOLOGY
R. R. McDonald 213-354-6186

The objective of this RTOP is to reduce the fire hazard associated with aircraft systems. This objective will be accomplished by research in two areas: (1) by modification of the fuel, and (2) development of analytical methods for predicting thermochemical behavior of the polymers in a fire environment. Fuel antimisting: fuel additives will be developed which will markedly reduce the mist formed when a fuel tank or line is ruptured, with a consequent reduction in the fireball which can form on ignition. The effectiveness of these antimisting agents appears to be related to the development of a high tensile viscosity, but also the effect is sensitive to high shear rates and temperature. A systematic study of such rheological behavior will be conducted to facilitate tailoring the additive and its concentration to varied use conditions. Thermochemical modelling: thermodynamic calculations and modelling will be accomplished to investigate the parameters that determine the potential for flashover and flame spread with emphasis on polymer thermal stability and identification of polymer degradation products. Although flashover is poorly understood, it is presumably highly dependent on the composition, thermal stability and degradation mechanism of the materials involved in fires. An important goal will be to define the flammability limits of mixtures of air and the smoke and flammable gases generated by polymers in the fire environment. A combustion model will be developed to predict the flammability hazard of a given situation and to provide criteria for new materials and configurations for greater fire safety. Condensed phase thermochemical phenomena will receive attention in the light of previous experimental and theoretical work on the burning of solid propellants.

W76-70111 **505-08-21**
Ames Research Center, Moffett Field, Calif.
AVIATION SAFETY RESEARCH AND TECHNOLOGY
D. R. Chapman 415-965-5065
(505-01-31)

The objective is to develop the technology base for fire safe aircraft structures utilizing fire resistant materials, and fire control systems such as detectors and fire extinguishants; to fire harden aircraft interior structures and in particular lavatories, galleys, cargo compartments, and aircraft interior passenger compartments, and to determine the degree of fire hardening against various fire threat levels of the above structures. This program addresses itself to fire hardening of wide body jet aircraft against the following fire threats (1) the in-flight fire, (2) the ramp fire, and (3) the post-crash fire. In regards to in-flight and ramp fires, the approach includes the establishment of the fire threat level that unattended areas such as lavatories can withstand without fire propagation in the passenger area. Fire resistant materials will be developed and applied in these areas to increase the fire hardening of these structures. Detectors and extinguishants will also be evaluated. In regard to post-crash fires, fire resistant structural panels and windows will be developed and evaluated for protection of the fuselage against external

fires. Solid fire extinguishants will be evaluated for use on engine nacelle fires for commercial and military aircraft.

W76-70112 **505-08-22**
Lewis Research Center, Cleveland, Ohio.
AIRCRAFT OPERATIONS AND SAFETY R&T
R. D. Siewert 216-433-4000

The objective is to provide a broad base of safety-oriented technology for identifying and defining the hazards associated with aeronautical systems; and establish criteria for aircraft design and operating techniques leading to reduction in accidents, loss of life and injuries, and loss of equipment. The approach is to define, recommend, and support research activities that provide solutions to problems impacting on the safety of aviation. Cooperate with other NASA Centers and Lewis Divisions to exploit unique facilities and engineering talents necessary for addressing these safety problems. Coordinate research results with the FAA, NTSB, DOD, other interested Government Agencies, and the aviation industry. Specific areas of current research activities include: lightning hazards, rotor burst protection, hi-energy brakes, and aircraft fire technology.

W76-70113 **505-08-22**
Langley Research Center, Langley Station, Va.
HAZARD AVOIDANCE AND ELIMINATION
R. E. Bower 804-827-3285

The objective is to provide basic technology for the improvement of the level of safety in aircraft operations with regard to natural atmospheric phenomena and aircraft-induced hazards. Experimental flight research and analytic studies are to be conducted in areas of aircraft trailing vortices and slant-range visibility measurements. Assistance will be provided to other agencies on these problems as requested.

W76-70114 **505-08-22**
Flight Research Center, Edwards, Calif.
AVIATION SAFETY - FLIGHT TESTS OF WAKE VORTEX MARKING SYSTEMS
L. C. Montoya 805-258-3311
(505-08-20; 514-52-01)

This RTOP covers FRC activities related to flight-test evaluations of environmentally acceptable vortex marking systems, specifically the JPL (Tetra Ethylene Glycol) system will be flight tested in FY-76.

W76-70115 **505-08-22**
Marshall Space Flight Center, Huntsville, Ala.
AVIATION SAFETY RESEARCH
E. A. Weaver 205-453-4629

Using the laser Doppler technique, systems and instrumentation will be developed for measuring natural and induced atmospheric flow phenomena concentrating on clear air turbulence (CAT) and aircraft wing tip vortices. System feasibility studies, design studies, analyses and tests with ground based laser Doppler instrumentation will be performed to determine operational requirements, specifications, constraints and capability. The three major tasks in the RTOP are; (1) - (Development and Test of a Clear Air Turbulence Detection System) Develop and test a laser Doppler clear air turbulence (CAT) detection system as appropriate on the ground and aboard an aircraft, evaluating test data and the findings as the basis for system modification to assure overall system performance goals. (2) - (Development and Test of a Scanning Laser Doppler Vortex System) Develop and test two- and three-dimensional systems for measuring atmospheric flow, concentrating on aircraft wing tip vortices. (3) - (Visible Scanning Laser Radar Visibility Studies) Study and test the capability of a visible scanning laser radar in determining airport slant range visibility.

W76-70116 **505-08-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HAZARD AVOIDANCE FOR AIRCRAFT IN FLIGHT
R. R. McDonald 213-354-6186

The objective of this effort is directed toward improving aircraft safety. Specific effort proposed includes: a practical approach to marking trailing vortices generated by large aircraft will be investigated, with emphasis placed on injection of nonpolluting particulates. A preprototype model will be designed and tested. Based upon these results, it will be installed on a light aircraft to demonstrate feasibility. Flight testing phase will utilize NASA-FRC facilities.

W76-70117 **505-08-22**
Ames Research Center, Moffett Field, Calif.
AVIATION SAFETY RESEARCH AND TECHNOLOGY - WAKE VORTEX HAZARD
C. T. Snyder 415-965-5567
(514-52-01)

A wake vortex avoidance system is under development by the FAA that will employ ground-based computation to determine safe separations for given aircraft pairs with consideration of current local environmental conditions. A part of the data base for the system will be provided by this RTOP and will include: development of criteria to define hazard boundaries for a range of aircraft sizes, evaluation of existing mathematical models for computing the response of an aircraft to a known vortex, and development of improved mathematical models for computing the response of aircraft to a known vortex. The hazard criteria will be developed through the use of piloted moving-base simulation. The existing and improved mathematical models will be verified using velocity data and aircraft response data obtained simultaneously during vortex penetrations. These data were obtained in flight tests with the Ames Learjet instrumented with a hot-wire anemometer.

W76-70118 **505-08-23**
Ames Research Center, Moffett Field, Calif.
HAZARD AVOIDANCE - DATA PROCESSING AND FLIGHT SIMULATION FROM AIRCRAFT ACCIDENT RECORDINGS
C. Thomas Snyder 415-965-5429
(505-08-22)

This is a cooperative program with the National Transportation Safety Board, Bureau of Aviation Safety (NTSB-BAS). The general objectives are to (1) develop improved data processing techniques for analyzing aircraft accident recordings, and (2) develop the capabilities at NASA-Ames to respond expeditiously when flight simulator analysis of an aircraft accident is deemed appropriate. Task 1 involves the investigation and evaluation of advanced data analysis methods (e.g., smoothing and parameter identification) for the processing of data from either the foil or digital flight recorders. These advanced methods will be used to obtain, from a limited set of accident data, a comprehensive scenario of the aircraft's position, velocities, orientation, configuration changes, etc., and other derived information which may not have been directly recorded. Task 2 involves the development of the capability to expeditiously simulate, using piloted flight simulators, a given aircraft accident. This flight simulator would then be used to aid the accident investigation. A key activity will be the establishment of a library of transport aircraft simulator models. The data from Task 1 would be used to help ensure that the flight simulations resulted in a faithful reproduction of the given aircraft accident.

W76-70119 **505-08-25**
Langley Research Center, Langley Station, Va.
WIDE-BODIED JET TRANSPORT OPERATING EXPERIENCES
R. E. Bower 804-827-3285

Statistical data on the operation experiences of wide-bodied jet transports collected prior to closure of the NASA VGH transport program will be analyzed and reported. Since no other operational flight data of this type exist for wide-bodied transports, this analysis will provide: (1) a means to study the operational practices of these aircraft to determine if aircraft size has instigated changes in these practices from procedures followed with smaller jet transports, (2) an assessment of the effect of atmospheric turbulence on heavier aircraft with respect to frequency of occurrence and magnitude, and (3) a comparison of gust and maneuver loads with design gust and maneuver loads.

W76-70120 **505-08-30**
Langley Research Center, Langley Station, Va.

CROSSWIND LANDING FOR STOL OPERATIONS
R. E. Bower 804-827-3285

The objective is to investigate STOL crosswind landing problems and methods of extending the crosswind limits for landing. A flight investigation will be conducted to determine the relation between airplane control, airplane response, piloting techniques, flight safety margins, and crosswind limits during STOL-type landing operations. A crosswind landing gear will be designed, built, and flight tested.

W76-70121 **505-08-31**
Ames Research Center, Moffett Field, Calif.
AIRCRAFT SYSTEMS OPERATIONAL SAFETY AND EFFICIENCY IMPROVEMENT
D. R. Chapman 415-965-5065

The objectives are to improve aircraft safety and efficiency on the runway through the utilization of advanced materials incorporated in aircraft tires and brake linings, to develop and evaluate new elastomer formulations for use in tires on high performance aircraft having wear and safety characteristics superior to those of state of the art tires, to improve aircraft braking by the utilization of improved materials for brake linings, and to develop and evaluate composite carbonaceous materials which serve as long wear and improved frictional materials. Thermal-oxidative degradation and basic wear mechanisms of state of the art and candidate aircraft tire tread elastomers will be investigated. Tread vulcanizates of new and improved elastomers in polyblends with artural rubber and/or cis polybutadiene will be evaluated with respect to wear and dynamic properties. A set of aircraft tire carcasses will be retreaded with a natural rubber/trans polypentenamer polyblend (as a follow-up to current work on tires retreaded with a natural rubber/vinyl polybutadiene polyblend) and evaluated in commercial airline operations as well as in special runway traction tests. Brake lining composites will be molded of p-polyphenylene, polybismaleimide, and branched polyphenylene. The processing and formulation parameters will be investigated. The key properties will be determined. These include friction, wear, thermal and oxidative stability. Selected composites will then be tested on a full scale dynamometer.

W76-70122 **505-08-31**
Langley Research Center, Langley Station, Va.
AIRCRAFT GROUND PERFORMANCE
R. R. Heldenfels 804-827-2042

The objective is to establish new concepts and techniques in aircraft systems design, testing, and operation which will permit increased operating efficiencies. Aircraft operations on prepared runways under adverse weather conditions and on certain unprepared surfaces present requirements of braking and steering systems, tires, and runway that are vital to aircraft safety and passenger comfort. The objectives of programs covered by this RTOP are: (1) to improve the performance of braking systems, (2) to improve the performance and lifetime of pneumatic tires, (3) to develop new landing gear systems that would permit operations on unprepared fields, including water, and permit continuous use of prime runways for all-weather operations, (4) to evaluate tire cornering behavior with and without braking such that high-speed turnoffs can be designed to increase the flow of traffic at congested airports, and (5) to relate the character of the runway surface to aircraft braking and steering performance. Research to meet these objectives will employ full-scale aircraft, landing gear systems and subsystems, and scaled pneumatic tires. The test facilities will consist of the Landing Loads Track, airport runways, including the landing research runway at Wallops Flight Center, ground test vehicles, flight-type aircraft simulators, and various laboratory equipment.

W76-70123 **505-10-11**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION - AERODYNAMICS
R. E. Bower 804-827-3285

The objective is to develop and demonstrate advanced technology that will permit the design of general aviation aircraft that are safer, more productive, and clearly superior to foreign competition. This work will be accomplished by analytical studies, model tests, and flight tests to develop and demonstrate improved airfoil sections, wing designs, control characteristics, handling qualities, stall/spin characteristics, drag reduction, ride comfort, and pilot information.

W76-70124 **505-10-12**
Ames Research Center, Moffett Field, Calif.
GENERAL AVIATION AERODYNAMIC PERFORMANCE TECHNOLOGY
L. Roberts 415-965-5066

The objective is to provide advanced technology for general aviation that will permit the design of future aircraft that are safer and more productive. Advanced wing designs will be developed having improved low-speed control and stall characteristics combined with improved cruise drag and stability. Stall envelopes of existing light aircraft will be expanded and improved through wind tunnel testing of various aerodynamic and control system modifications. In addition, promising future aircraft configurations will be studied which have potential for inherent or imposed stall immunity. The climb/cruise performance of general aviation aircraft will be improved by reductions in engine cooling losses and airframe drag of third level carrier type aircraft.

W76-70125 **505-10-13**
Flight Research Center, Edwards, Calif.
FLIGHT DYNAMICS - CONTROL AND DISPLAY
S. W. Gee 805-258-3311
(505-07-21)

The objective is to identify and demonstrate the optimum levels of stability control, and handling qualities for general aviation aircraft that can be achieved through the application of advanced technology; and to investigate methods that will reduce the noise signature of these airplanes. Flight and simulator studies will be continued in control display interactions. Degradation of system and component performance will be used in addition to mixing control modes between axes in order to define minimum system characteristics. Economical system mechanizations that provide these characteristics will be explored. Studies will be made of benefits, including direct lift/drag control devices in a flight path command mode of control.

W76-70126 **505-10-14**
Wallops Station, Wallops Island, Va.
ANALYSIS OF UNCONTROLLED TRAFFIC PATTERN FLOW DYNAMICS FOR LIGHT AIRCRAFT
Loyd C. Parker 804-824-3411

The objective is to collect and analyze general aviation piloting procedures and aircraft flight dynamics data to define significant performance and operational parameters during landing approach and departure from airports. A data base has been collected which is comprised of over 3000 three dimensional radar tracks of arrival and departure flight profiles and the corresponding environmental conditions which existed for each flight. Math models for the analysis and quantitative definition of pilot and aircraft performance and piloting procedures have been developed. Math models for analysis of the mid-air collision hazard in uncontrolled airspace, simulation of existing air traffic and for assessment of new air traffic pattern concepts have also been defined and prototype models demonstrated. Utilizing these models, pilot procedures will be characterized for various aircraft type and environments and simulations of various uncontrolled traffic pattern concepts conducted to minimize the mid-air collision hazard and improve community noise exposure created by present patterns.

W76-70127 **505-10-21**
Ames Research Center, Moffett Field, Calif.
HELICOPTER AERODYNAMIC PERFORMANCE, DYNAMICS AND NOISE
C. T. Snyder 415-965-5567
(505-10-22; 791-40-22)

This RTOP covers research on performance, dynamic loads, stability, control system, and noise characteristics of advanced edgewise rotor concepts and configurations. Analyses will be followed by large scale wind tunnel tests to evaluate configurations and provide a data base to improve analytical techniques. A

dynamic properties evaluation of the new Rotor Test Apparatus will be completed to insure applicability to a wide variety of rotor systems. The baseline rotor will be tested. The design and fabrication of an advanced research rotor will be initiated. This rotor will incorporate latest concepts of rotor airfoils, camber and twist etc. and will be used to evaluate helicopter dynamic load prediction methods for nonstandard rotors. The Controllable Twist Rotor will be tested to determine performance/stress tradeoffs. Design and construction of multicyclic flap systems for vibration/stress suppression will continue. The blade/vortex interaction study will be continued, and a rotorcraft drag reduction study will commence. Design and fabrication of optical elements for a laser velocimeter for application to rotor inflow studies in the 40- by 80-foot wind tunnel will be completed.

W76-70128 **505-10-21**
Langley Research Center, Langley Station, Va.
HELICOPTER AERODYNAMICS
R. E. Bower 804-827-3285
(505-10-23; 505-10-26; 514-53-01; 505-06-31)

Analytical and experimental studies will be made to identify factors contributing to the aerodynamic and structural characteristics of rotors. University grants and contracted studies will be continued to define wake geometry and analytical procedures which include wake characteristics in predicting airloads, structural response and aerodynamic performance. In-house experimental studies will be continued to better define unsteady local-flow parameters significant in the prediction of rotor blade section lift and drag. Analytical, wind-tunnel, whirl tower, and flight investigations will be made to determine performance, dynamic loads, vibrations, and wake flow characteristics of advanced rotor concepts, rotorcraft configurations, and tail rotor arrangements. These studies will be coordinated with the airfoil development research under RTOP 505-06-31, with the rotor aeroelastic and acoustic studies under RTOP 505-10-26 and with rotor systems development under 514-53-01. These programs will, in general, be carried out jointly with the Langley Directorate of the Army Air Mobility Research and Development Laboratory.

W76-70129 **505-10-22**
Ames Research Center, Moffett Field, Calif.
TILT ROTOR AIRCRAFT AERODYNAMIC PERFORMANCE, DYNAMICS, AND NOISE
C. T. Snyder 415-965-5567
(505-10-21)

This RTOP covers activity in research and technology for the tilt rotor aircraft program to provide a sound base for definition of performance dynamic loads, stability, control system and noise characteristics of advanced tilt rotor concepts and configurations. The basic in-house dynamic stability theory extended to coupled modes and feedback control synthesis in FY-75 will be extended to complete aircraft math modeling. In-house experimental studies will be initiated. Contracted analyses and tests will be continued to determine tilt rotor gust response and means for gust alleviation and blade load suppression. Contracted generalized controller studies for complete aircraft gust alleviation will be confined. A contract for wind tunnel dynamic data analysis techniques will be extended.

W76-70130 **505-10-23**
Ames Research Center, Moffett Field, Calif.
ROTORCRAFT FLIGHT DYNAMICS
C. T. Snyder 415-965-5567

An investigation will be made of the interaction between, and relative importance of helicopter stability and control characteristics, displays, and pilot workload on performance of specific military tasks (low-level maneuvers, terrain masking and unmasking; low light level operations; bob-up and weapons firing). The objective is to provide a data base to quantify the tradeoffs between system complexity and task performance so that cost effective design decisions can be made in the implementation of hardware devices on military helicopters. Fixed and moving-base piloted simulations will be used to evaluate task performance. Selected results will be verified with flight experiments using a variable stability helicopter as an in-flight simulator. The application of advanced control systems to Tilt Rotor aircraft will be examined, through analysis, piloted simulations and flight experiments in the Tilt Rotor Research Aircraft.

W76-70131 **505-10-23**
Langley Research Center, Langley Station, Va.
ROTORCRAFT FLIGHT DYNAMICS
R. E. Bower 804-827-3285
(513-54-02; 505-07-41)

The objective is to use broad capability helicopter in-flight simulators to primary tools, conduct research required to develop improved and certification criteria (primarily in the areas of handling qualities and overall flight characteristics) for the various classes of VTOL vehicles as well as for helicopters and other rotorcraft. The scope of the research includes consideration of manual IFR flight conditions, as well as consideration of advanced vehicles having automatic and active control capability with satisfactory provision for pilots to monitor and take over flight control manually with particular emphasis on flight in the terminal area. Representative types of problems to be investigated include defining the requirements and flight/operational characteristics of advanced flight control systems including active controls, inherent and augmented stability, cockpit displays, pilot controls, vehicle/pilot interfaces with ground based and onboard navigation systems for manual flight in IFR conditions, and vehicle/pilot interfaces with automatic flight systems. The VALT CH-47 will be instrumented to provide a highly flexible and efficient replacement for the CH-46 in-flight simulator during FY 1976. The SH-3A will be used for cockpit display - pilot workload studies.

W76-70132 **505-10-24**
Langley Research Center, Langley Station, Va.
ROTORCRAFT CIVIL HELICOPTER TECHNOLOGY
R. E. Bower 804-827-3285
(505-10-21; 505-10-23; 505-10-26)

The objectives are: (1) to identify in critical disciplinary areas, the projected requirements, and associated criteria for achieving successful and acceptable civil operations, and to evaluate existing vehicles in meeting these requirements; (2) to assess the extent to which existing advanced technology can be applied to meet projected requirements, and to identify areas requiring additional research; (3) to conduct vehicle and systems design application studies utilizing existing advanced technology; and (4) to carry out key experimental evaluations which are deemed critical to industry acceptance, and use of promising advanced technology features. Studies will be carried out both through analytical, design, and systems studies and through experimental evaluations of selected systems in simulated operational environments. The program will utilize principally contractual effort, plus some in-house effort in flight research experiments.

W76-70133 **505-10-26**
Langley Research Center, Langley Station, Va.
ROTOR ACOUSTICS AND AEROELASTICITY
R. E. Bower 804-827-3285
(505-10-21; 505-10-25)

The objective of this plan is to develop technology related to the aeroelastic and noise characteristics of rotors, and to use this technology in developing and validating adequate design prediction methods. Technical areas of interest include methods of predicting aeroelastic stability characteristics of rotors in hover and forward flight, vibration characteristics of helicopters and means for reducing of alleviating excessive vibrations, unsteady rotor aerodynamics, noise source identification, improved noise prediction techniques, and means for controlling the noise from helicopter rotors. Work will continue on the establishment of a Generalized Rotor Aeroelastic Model (GRAM) to be used for experimental correlation of advanced aeroelastic stability analyses being developed in-house and under contract. Data from tests of Bell research rotor configuration on GRAM will be used to correlate UCLA stability analysis. An analytical study to develop means for predicting the vibration characteristics of complete helicopter configurations will continue. Full scale rotor vacuum chamber tests will provide data identification techniques. Development of a rotor unsteady lifting surface theory will continue. A program to investigate the use of active controls for vibration control will be initiated. Rotor tower tests on four,

three, two, and one-bladed rotor configurations to measure high frequency fluctuating loads will be completed. Flight tests of UH-1 Ogee tips will be conducted. Critical aeroacoustic model experiments on tip vortex modifications will be established.

W76-70134 **505-10-27**
Ames Research Center, Moffett Field, Calif.
ADVANCED TILT ROTOR AERODYNAMICS
W. L. Cook 415-965-5559

The objective of this effort is to provide technical data to enable rotor and control system design optimization for advanced tilt rotor aircraft. Design information for control systems that will maximize aircraft maneuver capability, reduce rotor loads, and reduce tilt rotor sensitivity to gust and turbulence will be developed. Variable geometry rotors will be investigated to determine potential improvements in rotor and aircraft cruise performance. A dynamically scaled wind tunnel model of a tilt rotor with a composite blade hingeless rotor will be tested under contract. The parametric variation in rotor and aircraft loads during transition will be investigated and the current tilt rotor mathematical model updated. The performance gains and blade load reduction achievable by putting cyclic control under pilot command will be assessed. The existing data base for hingeless rotor performance will be extended to a simulated cruise speed of 300 knots. Small-scale telescoping blade rotor tests will be performed under contract in FY 1977. The effect of tilt angle and flight speed on the transition flight boundaries, rotor performance and stability characteristics will be determined.

W76-70135 **505-10-31**
Ames Research Center, Moffett Field, Calif.
VTOL AERODYNAMIC PERFORMANCE
C. T. Snyder 415-965-5567
(505-03-12)

This RTOP covers research on the aerodynamics, performance, stability and control of promising jet-lift VTOL commercial and military transport configurations, including a better understanding of propulsion-aerodynamic interactions. Analytical methods for predicting these characteristics will be improved. Wind-tunnel investigations of a large-scale model of a lift-fan research aircraft both in and out of ground effect will begin. Large-scale wind tunnel investigations of aircraft components will continue, as will wind-tunnel research on the noise generated by lift-fan jet-lift VTOL aircraft at forward speed. Analytical studies to improve prediction methods will begin. Studies of advanced augmentors at both large and small scale will continue. Theoretical and experimental studies of cruise performance of lift/cruise fan powered VTOL aircraft will continue.

W76-70136 **505-10-31**
Langley Research Center, Langley Station, Va.
VTOL AERODYNAMIC PERFORMANCE
R. E. Bower 804-827-3285
(505-11-41)

This research is a continuing three-part effort in VTOL aerodynamics involving applied fluid mechanics phenomena, combat aircraft, and transport aircraft. The basic research objective is to provide the technology required for improved performance, stability, and control of promising VTOL configurations applicable to military combat aircraft and also to civil and military transports. Limited fundamental studies will be continued in-house and by contract to develop, through theory and experiment, engineering design methods for optimizing the aerodynamics of VTOL aircraft. University grants will augment the in-house analytical effort. Major emphasis will be placed on wind tunnel investigations of combat aircraft configurations and promising lift-fan transports for both military and civil application. Exploratory research will be conducted in an attempt to integrate V/STOL capability into both conventional and highly maneuverable fighter aircraft designs. This research will include configurations suitable for shipboard operations where no catapults or arresting gear is used and embraces various propulsion schemes such as ejectors, thrust deflectors, and lift-plus-lift/cruise engines.

W76-70137 **505-10-32**
Ames Research Center, Moffett Field, Calif.
VTOL FLIGHT DYNAMICS
C. T. Snyder 415-965-5567
(505-10-35)

Design and handling qualities criteria will be developed for satisfactory manual control of jet or lift-fan VTOL aircraft. Two areas are of primary concern. The first is to develop advanced flight control systems that overcome deficiencies of existing systems designed for these aircraft. The second is to study and solve specific problems that are associated with adapting VTOL aircraft to operations from ships. A particular advanced controller concept, called the state rate feedback implicit model follower, will be studied in a piloted moving-base simulation and compared directly with a conventional response feedback controller. Flight research in the hovering mode, using the X-14B aircraft, will also be employed to study advanced control concepts. Piloted moving-base simulation will also be employed to study special problems involved in manual control of the take-off, approach, and landing of VTOL aircraft from Navy ships during severe weather conditions. The techniques developed will be employed in simulations required for the NASA/NAVY Lift/Cruise Aircraft Technology Program (RTOP 505-10-35) as well as in simulations to meet the objectives of this RTOP.

W76-70138 **505-10-34**
Ames Research Center, Moffett Field, Calif.
SIMULATION MATH MODELS OF ADVANCED TRANSPORTS
C. T. Snyder 415-965-5567

Simulation models of all important aircraft concepts in the CTOL, RTOL, STOL and V/STOL commercial transport classes are required to support the study of terminal area efficiency factors. To permit valid comparisons, the models of all competing concepts must be designed to the same level and technology and, where possible, for the same mission. Simulation models of promising concepts will be developed, commensurate with the requirements for computer storage and speed of execution, yet consistant with the aim of providing representative pilot handling qualities. The initial effort will concentrate on modelling and simulation on the Ames Flight Simulator for Advanced Aircraft of a 1985 technology level 100 passenger tilt rotor vehicle, including its ride quality and gust alleviation control system. The next aircraft types to be modeled will be commercial derivatives of the Air Force AMST vehicles and a low wing loading STOL with ride quality control.

W76-70139 **505-10-35**
Ames Research Center, Moffett Field, Calif.
NASA/NAVY MULTIMISSION V/STOL AIRCRAFT TECHNOLOGY DEVELOPMENT
W. L. Cook 415-965-5903
(514-54-01)

This RTOP is to cover the Ames Research Center's Technology Development Program for the potential FY-77 New Start for the NASA/Navy Multipurpose V/STOL Technology Aircraft. These Technology Development Programs are being equally cofunded by the U.S. Navy, and Lewis Research Center is supporting the Technology Programs for the lift/cruise propulsion system. This research aircraft would have V/STOL capability provided by integrated propulsion/control system having lift/cruise fans for hover and the cruise modes of flight. The development of the technology would allow proceeding with the lift/cruise fan development in FY-76 followed by start of fabrication of the research aircraft in FY-77. The Technology Development Program includes: (1) small-scale and large-scale wind tunnel tests of the research aircraft to be conducted in the Ames 40- by 80-Foot and the Langley V/STOL Wind Tunnels, (2) static tests of large-scale thrust deflectors for the cruise fans, (3) integrated control/propulsion system studies and tests, (4) conceptual design studies of the potential research and technology aircraft for NASA and Navy flight investigation purposes, including estimates of costs and schedules for budgetary purposes prior to proceeding with the research aircraft project, and (5) development of math models based on existing data for 6-degree of motion simulation of the potential research aircraft during FY-76.

W76-70140 **505-10-41**
Langley Research Center, Langley Station, Va.
POWERED-LIFT AERODYNAMICS
R. E. Bower 804-827-3285
(769-38-02; 769-39-03)

The objective is to provide the technology required to improve the low-speed performance and aerodynamics and high-speed cruise performance of powered-lift aircraft configured for short-haul applications. Primary emphasis in FY-1976 will be placed on upper-surface blowing (USB) concepts which employ attached exhaust flow on the upper surface of the wing during terminal-area operations. In-house and contract efforts which utilize wind tunnels, static test rigs, and theoretical and analytical approaches will be directed toward providing data and prediction techniques pertaining to aerodynamic performance.

W76-70141 **505-10-41**
Ames Research Center, Moffett Field, Calif.
POWERED-LIFT (STOL/RTOL) AERODYNAMIC PERFORMANCE
C. T. Snyder 415-965-5567
(505-06-23)

This RTOP covers Ames efforts in R/STOL Aerodynamics and noise. The goal is to provide aerodynamically efficient, quiet, and mechanically simple powered lift systems having RTOL and STOL performance. The experimental investigations at large and small scale as well as theoretical studies for improving augmentor performance and acoustics will continue. General support in the investigation of other powered lift concepts will be continued in both theoretical and experimental effort. Supporting investigations of wind tunnel wall effects for STOL aircraft, ground effect, and noise characteristics of STOL aircraft will be conducted under this RTOP.

W76-70142 **505-10-42**
Ames Research Center, Moffett Field, Calif.
STOL/RTOL FLIGHT DYNAMICS
C. T. Snyder 415-965-5567

Generalized analytical studies, ground-based simulation, and flight research will provide data for revision and extension of existing handling qualities and certification criteria for STOL aircraft. The data will apply to the following critical areas: flight-path, airspeed, and attitude control; landing flare in presence of ground effect; roll and yaw control for cross-wind landing; and the control of a powered-lift STOL following loss of an engine. Tentative airworthiness criteria based on studies of representative powered-lift aircraft, together with techniques for determining compliance will continue to be developed in cooperative FAA/NASA piloted simulation studies on the Flight Simulator for Advanced Aircraft. These results will contribute to generalized criteria for all concepts. Flight research in both handling qualities and certification areas will be accomplished using the Augmentor Wing Jet STOL Research Aircraft; a DHC-6 aircraft equipped with hinged-plate spoilers (joint NASA/FAA program); and the QSRA, YC-14 and YC-15 aircraft as they become available. A simulation experiment will be conducted to develop means and procedures for minimizing landing field length for short-haul RTOP aircraft.

W76-70143 **505-10-43**
Ames Research Center, Moffett Field, Calif.
STOL - CRUISE AUGMENTOR DEVELOPMENT PROGRAM
Richard H. Petersen 415-965-5859
(505-10-41)

This work will cover the Ames research effort to explore the possible benefits to the cruise performance of augmentor-wing jet STOL aircraft by operation of the augmentor in the cruise flight regime. The primary goals of this study are (1) to develop an efficient augmentor configuration for STOL aircraft over the entire flight Mach number range, with particular emphases on the cruise speed; (2) to improve the overall propulsive efficiency of STOL aircraft; and (3) to attain high wing efficiency utilizing the augmentor system as a boundary layer control device; i.e., with a suitable design it is expected to maintain a 'flat top' pressure distribution over almost the entire upper surface of the wing (thus emulating the so-called super-critical wing section). Because little is known about behavior of the augmentor flap at STOL-cruise speeds, it is proposed to carry out the research work in a step-by-step or multi-phase in-house and contractual program. Thus, tests will be conducted in low speed tunnels and then, high speed tunnels, using both 2 and 3 dimensional STOL-augmentor configurations. The effort will be supported by appropriate analytical analyses.

W76-70144 **505-10-44**
Langley Research Center, Langley Station, Va.
POWERED-LIFT ACOUSTICS AND LOADS
R. E. Bower 804-827-3285
(769-38-02; 769-39-03)

The objective is to provide the technology required to improve the terminal-area noise and to define the loads of powered-lift aircraft configured for short-haul applications. Emphasis in FY 1976 will be placed on upper-surface blowing (USB) concepts which employ attached exhaust flow on the upper surface of the wing during terminal-area operations. In-house and contract efforts which utilize wind tunnels, acoustical laboratories, outdoor test rigs, and theoretical and analytical approaches will be directed toward providing data and prediction techniques pertaining to acoustics, and loads phenomena. Studies will also be carried out of integration of these results into optimal configurations.

W76-70145 **505-11-12**
Ames Research Center, Moffett Field, Calif.
SUBSONIC/SONIC AIRCRAFT AERODYNAMIC PERFORMANCE
Richard H. Petersen 415-965-5990
(505-06-31; 791-93-62)

The objective of this investigation is to determine the aerodynamic performance, stability and control characteristics, of the R.T. Jones oblique wing transport aircraft configuration at subsonic, transonic and low supersonic speeds, and to provide adequate aerodynamic prediction methods for this class of vehicle. This information will be used for mission studies to assess the potential of antisymmetric configurations for advanced transport application. Concurrently, analytical and experimental investigations of nacelle-airframe configurations are underway using a scaled wind tunnel oblique wing transport model designed for flight up to $M = 1.2$. The performance of wind tunnel model will be compared with analytical predictions to assess the validity of the methods used.

W76-70146 **505-11-13**
Flight Research Center, Edwards, Calif.
OBLIQUE WING FLIGHT TEST TECHNOLOGY
William H. Andrews 805-258-3311
(516-50-10; 505-11-12)

This test program will be conducted in two phases and will be directed toward the operation of an RPV and full-scale manned airplane modified to demonstrate the oblique winged configuration concept developed by R. T. Jones of the Ames Research Center. The initial program phase will consist of testing an RPV, Firebee 2, particularly in the critical regions of the projected flight envelope. The second phase will be directed to flying a manned LTV F-8 airplane to fully demonstrate and gain industry acceptance of the concept. Both vehicles will be modified to incorporate essentially an elliptical, full-span, variable-sweep wing (Lambda = 0 deg to 60 deg) fabricated to standard structural design specifications. The incorporation of conventional lateral control and high lift devices in the wing or other alternatives will be considered in the development stages of these programs. Basic control and stability augmentation system modifications to the test vehicles will also be assessed in the early development phase of each vehicle, respectively. The objective of the flight programs will be to demonstrate the feasibility and utility of the concept by evaluating the following:

W76-70147 **505-11-13**
Ames Research Center, Moffett Field, Calif.
OBLIQUE WING FLIGHT TEST TECHNOLOGY
R. H. Petersen 415-965-5881

The primary objective of this project is to develop and improve analytical and empirical prediction techniques that will provide

more accurate estimation of aircraft dynamic flight behavior from static wind tunnel data. Investigations of the currently used methods for predicting dynamic derivatives from static aerodynamic data and methods based on wind tunnel flight-data correlations will be made and effort will be made to improve these methods and develop new methods where appropriate. Initial efforts under this project will be directed at developing the NASA capability for predicting the dynamic behavior of oblique wing aircraft based on static wind tunnel and calculated data. An oblique wing remotely piloted aircraft will be wind tunnel tested and the aerodynamic data will be used to develop a simulation of the aircraft. The aircraft will then be flown to generate the actual dynamic behavior. The dynamic derivatives will be extracted from the flight test data. Correlation of the flight determined values with the wind tunnel data and the predicted derivatives will be used as a guide in the effort to develop improved prediction techniques.

W76-70148 **505-11-14**
Ames Research Center, Moffett Field, Calif.
CIVIL AIRCRAFT DEVELOPMENT TESTING - INDUSTRY AND OTHER GOVERNMENT AGENCIES
R. H. Petersen 415-965-5848

Civil aircraft research and development generally require supporting wind tunnel investigations. In particular, Reynolds number effects on high-lift system characteristics at take-off and landing speeds, and performance, stability and control characteristics and aerodynamic loads assessment at transonic and supersonic speeds need experimental evaluation. Notably the 12-Foot Pressure Wind Tunnel and the Unitary Plan Wind Tunnel are well-suited for such investigations and, when technically appropriate, are utilized accordingly. Proprietary testing at the request of a particular company is charged for in accord with NASA policy. Testing for other government agencies is done without transfer of funds.

W76-70149 **505-11-15**
Langley Research Center, Langley Station, Va.
HIGH-SPEED AERODYNAMICS
R. E. Bower 804-827-3285

The technical objective of this work is to provide the analytic methodology and a background of aerodynamic data throughout the speed range (up to about M = 4.5) for defining and optimizing the aerodynamic performance of high-speed aircraft configurations. The approach to be used will employ both theoretical and experimental investigations of generalized aircraft configurations to develop techniques for increasing aerodynamic efficiency; to determine means of managing the aerodynamic center variation with Mach number to attain low static margins without encountering regions of static instability; and, to develop new aerodynamic control concepts to provide maximum aerodynamic control effectiveness with a minimum of control force. Attempts will be made to formulate original theories and to adapt existing theories to practical usage in computing programs. Limited wind-tunnel tests will be made to verify, to establish limits of, and where appropriate, provide empirical corrections to theoretical results. Interactive computer graphics will be developed for efficient use of both manpower and computer power.

W76-70150 **505-11-16**
Langley Research Center, Langley Station, Va.
LONG-HAUL AIRCRAFT AERODYNAMICS AND PROPULSION SYSTEM INTEGRATION
R. E. Bower 804-827-3285

The objective is to provide advanced technology required to improve the aerodynamic performance of advanced medium-to-long-haul transport aircraft without undue degradation to other characteristics. Emphasis will be directed toward technology development applicable to next generation transport designs configured to conserve fuel and be environmentally acceptable, and toward advanced very large aircraft for cargo or other applications. In-house and contract efforts which utilize wind tunnels, acoustic laboratories, outdoor test rigs, and theoretical and analytical approaches will be directed toward providing a data base and prediction techniques pertaining to subsonic aerodynamic performance for both cruise and high-lift conditions, propulsion system integration, stability and control, and where appropriate, acoustic and loads phenomona.

W76-70151 **505-11-21**
Ames Research Center, Moffett Field, Calif.
MILITARY AIRCRAFT - AIRCRAFT AERODYNAMICS
Richard H. Petersen 415-965-6116
(505-06-95; 505-04-11)

Experimental and analytical studies will be made to provide the aerodynamic technology for design of advanced military aircraft. Large scale wind tunnel studies will be conducted on components and integrated configurations to determine the mutual aerodynamic interference effects between the airframe and propulsion system for military aircraft at subsonic, transonic, and supersonic speeds. The effect of fuselage geometry and inlet location on aircraft and inlet performance will be determined. Various numerical analysis and approximation techniques will be employed to serve as a basis for the detailed numerical study, and to aid in defining cost effective experimental programs. Wind tunnel studies and existing tunnel results will be made over the Mach number range to verify the analysis and to evaluate the mutual aerodynamic interference effects between the airframe and propulsion system that are beyond the scope of present analytical methods. It is estimated that this effort will extend thru FY-79.

W76-70152 **505-11-21**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT AERODYNAMICS
R. E. Bower 804-827-3285

The technical objective of this work is to develop the aerodynamic technology base for the design of future military aircraft. The approach to be used will combine both analytical and experimental studies of the integration of advanced aerodynamic concepts such as supercritical aerodynamics, wing warp, maneuver devices, thrust-induced lift, and component interference in the design of complete aircraft configurations. Particular emphasis will be placed on the improvement of performance and stability-and-control characteristics in the high angle-of-attack range at subsonic, transonic, and supersonic speeds.

W76-70153 **505-11-22**
Langley Research Center, Langley Station, Va.
MISSILE AERODYNAMICS
R. E. Bower 804-827-3285

The objective is to provide a technology base such that maximum advantage of aerodynamic effects are realized in missile performance. Identify new aerodynamic/missile concepts and establish the data base to evaluate the performance of the concept. The approach to be used will combine both analytical and experimental techniques. Studies will provide the technology for advanced missiles at all speeds for various mission requirements including the aerodynamic stability and control characteristics of surface-to-air, air-to-ground, air-to-air, and surface-to-surface missiles with wing, tail, canard, or jet controls. Emphasis is to be given to aerodynamic problems of fundamental importance to a class of configurations to permit a later selection for a specific development. Studies will include rocket as well as air-breathing systems with special consideration being given to inlet-airframe integration.

W76-70154 **505-11-22**
Ames Research Center, Moffett Field, Calif.
MISSILE AERODYNAMICS
Richard H. Petersen 415-965-5859
(505-06-95)

This program is aimed at providing consistent basic knowledge, experimental tools, data, prediction methods, and theory for determining the aerodynamic and control characteristics of high-maneuver missiles for the 1980's. The basic approach is to carry out four highly integrated tasks. Task 1, develop prediction methods for estimating static force and moment characteristics at high angles of attack (to 180 deg) and provide experimental verification on basic missile-type bodies. Task 2, determine dynamic stability characteristics through wind tunnel experiments

and provide data for formulation of semi-empirical prediction methods. A new large scale oscillatory apparatus will be fabricated for this task. The large rotary apparatus being constructed under RTOP 505-06-95 will also be used. Task 3, provide both theoretical and experimental tools to evaluate the influence of rocket exhaust plumes on the missile aerodynamic and control characteristics. Theoretical methods will be developed and experimental investigations will be conducted to determine adequate exhaust simulation techniques for extensive wind tunnel tests on configurations explored in Task 1. Task 4, upgrade current prediction methods for calculating aeroelastic effects on configurations under high loads due to aerodynamic and thrust controls. Increase the capability of the computer program, FLEXSTAB, and conduct experimental tests to verify improvements.

W76-70155 **505-11-23**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT - VECTORED THRUST MANEUVERABILITY
R. E. Bower 804-827-3285

The objective is to expand VIFF studies of the Harrier to maximum speed and thrust. Flight trials of the Phase 2 Joint NASA/U. K. VIFF flight research program will be completed in the U.K. using a modified Harrier aircraft supplied by the U.K. These trials will be in two parts: (1) air-to-air and (2) air-to-ground.

W76-70156 **505-11-24**
Flight Research Center, Edwards, Calif.
F-15 STALL/SPIN - RPV FLIGHT TESTS
G. P. Layton 805-258-3311

This program involves the design and construction of three 3/8-scale remote piloted F-15 fighter aircraft configurations to be air-launched, flown through high angle-of-attack maneuvers and recovered by horizontal landing on Edwards Dry Lake or by parachute recovery. These vehicles are to be flown to gather needed flight data at angle-of-attack values at, near, and beyond the aircraft stall and departure. The overall objectives are to develop a remote controlled test technique that is suited to stall/spin type research; to obtain high angle-of-attack data specifically for a 3/8-scale F-15 configuration up to and including post-stall, pre-spin conditions; and to assess advanced control systems in pre-stall, post-stall, and pre-spin flight.

W76-70157 **505-11-25**
Flight Research Center, Edwards, Calif.
RPRV CAPABILITY DEVELOPMENT
B. M. Kock 805-258-3311

This RTOP covers a Remotely Piloted Research Vehicle (RPRV) capability development program. The program will develop a baseline capability for performing flight research with supersonic, maneuverable, vehicles. Particular emphasis will be placed on developing the existing FRC RPRV operating systems to be compatible with this class of vehicle. A Firebee 2, target drone (BOM-34 E/F) converted to an RPRV, will be used. The vehicles will be on loan from the USAF. The technique development program will consist of a series of flights using MARS recovery and a series of flights using horizontal landing as the recovery technique. During these flights the performance and maneuvering envelope of the airplane will be explored so as to meet the program objectives. To accomplish the program the vehicles will be modified with a complete research instrumentation capability. This instrumentation along with the RPRV command and control capability will develop the Firebee 2 into a versatile high performance research test bed.

W76-70158 **505-11-31**
Langley Research Center, Langley Station, Va.
HYPERSONIC AIRCRAFT AERODYNAMIC TECHNOLOGY
R. E. Bower 804-827-3285
(505-04-31; 501-22-06)

The purpose of this work is to provide the technology for the design of efficient, practical hypersonic airbreathing aircraft. A number of aircraft systems are being studied. These include hypersonic transports, military strike and reconnaissance vehicles, hypersonic research airplanes, and the airbreathing launch vehicle. The airbreathing launch vehicle which is potentially capable of providing a truly low cost space logistics systems can fill an expected need in the NASA/DOD program in the post 1990 time period. The hypersonic transport, with its long-range capability and cruise sonic boom levels that may be acceptable over populated areas, has the potential of providing a major step in air transportation in the latter part of the century. Airbreathing vehicle systems must fully exploit synergistic interactions between aerodynamics, propulsion, structures, trajectory selection, etc., to achieve maximum overall efficiency and operational flexibility. Detailed work on configuration concepts, reliable prediction techniques, full-scale Reynolds number effects, engine-airframe integration, etc., will be vigorously pursued to provide the technological base necessary. The technology for all three systems needs to be demonstrated in flight before commitment to mission hardware is made. The X-24C research aircraft concept resulting from the Joint USAF-NASA study completed in January 1975 will be used as a focal point in the technology development.

W76-70159 **505-11-41**
Langley Research Center, Langley Station, Va.
DOD ASSISTANCE - SPECIFIC MILITARY DEVELOPMENT PROGRAM
R. E. Bower 804-827-3285

The objective is to determine, at specific request of DOD, the aerodynamic characteristics of models and model components at subsonic, transonic, and supersonic speeds. Current emphasis is focused on the USAF B-1, USAF F-16, USAF F-5E, USAF AFTI configuration and several missile concepts. Anticipated emphasis will be focused on DOD requested (program interest to NASA) generalized research programs on methods to improve aircraft maneuverability. Results will be obtained by means of wind-tunnel investigations conducted over appropriate ranges of aerodynamic variables to determine forces, moments, and loads as well as by the use of the many available analytical programs. Analysis of the results will be performed and selected results will be documented.

W76-70160 **505-11-41**
Ames Research Center, Moffett Field, Calif.
DOD ASSISTANCE
L. Roberts 415-965-5848
(136-63-02; 760-74-01; 764-74-01)

Technical assistance, consultive services, and facility support will be provided to the DOD in support of military aircraft and missile development programs. Included are research efforts to aid in assuring satisfactory aerodynamic and handling qualities of piloted aircraft and in assuring satisfactory flight path and attitude control of these aircraft in given automatic flight modes, such as radar-guided approaches and landings on an aircraft carrier. Included also are efforts to define and develop techniques for improvement of marginal or unsatisfactory characteristics of new airplane designs. Wind tunnels, flight simulators, and central computer facilities (360), together with applications of advanced control theory, will be employed as required. Specific weapon systems programs for which support is planned during FY 1976 include the B-1, AV-8+, 2-Kiloton Surface Effects Ship, YC-15, AFTI, Navy Quiet Torpedo, A-7E ACLS, Lightweight Fighter, Point Defense Missile and EA-6B APC/ACLS.

W76-70161 **505-11-41**
Lewis Research Center, Cleveland, Ohio.
OUTSIDE AGENCY SUPPORT AERONAUTICS TESTING
D. N. Bowditch 216-433-4000

The objective is to support requests from the Department of Defense, Department of Transportation and other federal agencies outside of NASA for aerodynamic testing in the facilities of the Lewis Research Center.

Aeronautics System Studies

W76-70162 **791-40-03**
Ames Research Center, Moffett Field, Calif.
CIVIL AIR TRANSPORTATION SYSTEMS AND CONCEPT STUDIES
L. J. Williams 415-965-5887

The objective of this RTOP is to provide systems analyses of future civil air transportation systems and concepts in order

to identify promising aeronautical systems, determine optimum characteristics, and define technology requirements and costs associated with such systems. Studies will be conducted for a variety of air transportation systems including short haul, both commuter and regional, and long haul, both domestic and international. Emphasis is to be placed on fuel economy in future air transportation systems. Total system studies will be carried out considering all of the interactions between aircraft, airports, airways, community impact, and economics (both within the aviation industry and on a national basis). Studies of a short term nature will be conducted in support of the aeronautical program planning activities of ARC and OAST. This RTOP is responsive to the program objectives related to Civil Air Transportation Studies, fuel conservation in aeronautics, and systems analysis methodology and support.

W76-70163 **791-40-04**
Ames Research Center, Moffett Field, Calif.
MILITARY AIRCRAFT CONCEPT ANALYSIS AND METHODOLOGY DEVELOPMENT
L. Roberts 415-965-5881

The objective of this RTOP is to develop a methodology to aid in defining the benefits of new aeronautical technology and to increase the value of NASA's research to DOD for preliminary design studies and evaluations. The approach will be continued incorporation of advanced technologies into in-house aircraft synthesis programs and exercising these programs by analysis of aircraft systems intended to meet mission requirements obtained from or developed in cooperation with appropriate DOD planning personnel. Historically, NASA has supported the DOD by generating advances in technology and by providing analytical and test assistance during the development of specific designs. NASA is involved in assessing the readiness of advanced technology and assisting the military in determining its effect on future aircraft.

W76-70164 **791-40-08**
Langley Research Center, Langley Station, Va.
CIVIL AIR TRANSPORTATION
R. E. Bower 804-827-3285
(516-50-20)

The objectives are: to develop an improved model for calculation of variable life-cycle aircraft operating costs with emphasis on better evaluation of the impact of advanced technologies; to determine future market growth, mission requirements, and overall transportation system demands which could impact design features of both conventional and advanced air cargo concepts, and to evaluate potential market response to the introduction of an advanced air freighter with significant improvements in efficiency, productivity and payload capability; and to assess the technological impact of advanced and unconventional aircraft on the national interest and public sector through predicted interaction with the economic, social, environmental, political and legal systems in both domestic and international arenas. A joint effort by an operating airline and an aircraft manufacturer will be conducted to develop improved methodology for determining aircraft operating costs. The Phase 1 contract jointly funded and administered by NASA and the National Science Foundation to assess the technology impact of large air transports will be completed and the results evaluated. A follow-on Phase 2 effort will be broader in scope focusing on the most promising interface for all transportation elements of a comprehensive intermodal system. A contractual study will be initiated to identify the unique transport needs of developing countries and to propose an air transport system to serve those needs. Contractual studies will provide an in-depth analysis of those specific factors which would impact the design features and determine the potential impact on freight market shares.

W76-70165 **791-40-11**
Langley Research Center, Langley Station, Va.
STUDIES OF ALTERNATIVE AIRCRAFT FUELS AND GROUND SYSTEMS
R. E. Bower 804-827-3285

The objectives are: to generate by exploratory and by systems studies sufficient technological data, comparable to that already available on airplane design, for the purpose of defining and describing an air transportation system in which conventional jet fuels are replaced by liquid hydrogen as a measure to conserve natural crude petroleum. Data from initial studies indicate options and opportunities to further the evolutionary process of defining a hydrogen air transportation system. Under this RTOP, contract studies will be extended to investigate the most promising option and opportunities.

W76-70166 **791-40-15**
Ames Research Center, Moffett Field, Calif.
CIVIL AIRCRAFT ANALYSIS AND METHODOLOGY DEVELOPMENT
R. H. Petersen 415-965-5881

The objective of this research is to develop and use an overall system synthesis capability which can identify the best aircraft characteristics for various air transportation systems. Mathematical models of the air vehicle elements will be used and verified by comparison with operational situations. Quick response studies of civil air transports will be conducted to identify critical research areas, assess energy consumption and provide information for cost benefit studies. Specific studies of aircraft optimized for cargo, reduced energy consumption, and reduced noise and wake-vortex hazard will be initiated. These in-house studies will provide guidance for possible future contract studies.

W76-70167 **791-40-18**
Ames Research Center, Moffett Field, Calif.
STUDY OF POTENTIAL UTILITY OF RPV'S (REMOTELY PILOTED VEHICLES) FOR CIVIL APPLICATIONS
R. H. Petersen 415-965-5881
(516-50-10; 505-11-12; 505-11-13)

Studies will be conducted to identify and describe the potential civil market for RPV's, to assess the associated benefits and costs of using these vehicles, and to identify likely candidate vehicle concepts and the technology required to satisfy civil markets. The study will include an assessment of the impact of safety, reliability and environmental requirements on the future use of civil remotely piloted vehicles. A contracted study will be completed in about April of 1976.

W76-70168 **791-40-22**
Ames Research Center, Moffett Field, Calif.
ROTORCRAFT MAINTENANCE COSTS METHODOLOGY DEVELOPMENT
W. L. Cook 415-965-5559
(505-10-22; 505-10-21)

This RTOP covers evaluation of current rotorcraft maintenance cost experience of both civil and military operations and the establishment of techniques for projecting maintenance cost of advanced rotorcraft, in particular the tilt rotor concept. Commercial and military operations will be surveyed to provide a data base on current experience. Projections of likely technological developments in subsystem design and the effect on rotorcraft maintenance costs will be made. Multiple regression techniques will be used to develop the importance of parameters such as vibration level, mission cycle vs. flight hours, etc. as well as the effects of major technical design differences, if pertinent, in determining good maintenance cost estimating relationships.

W76-70169 **791-40-23**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY ASSESSMENT OF INTERCITY TRANSPORTATION SYSTEMS
H. Hornby 415-965-5895

The objectives of this RTOP are to enhance NASA's contribution to our nation's ability to provide adequately for its future transportation needs, including modal systems and their energy requirements; and to determine the possible impacts on the timeframe and goals of aviation and air transportation R&T of the more promising future intercity transportation systems and corresponding urban structures. The approach will be based on extending the NASA/DOT joint agency Technology Assessment of Intercity Transportation Systems into Phase 2 activities. Phase 2 shall include the selection and initiation of follow-on studies of critical issues, constraints, barriers (identified in the

Phase 1 technology assessment) which require further definition toward future objectives of the NASA aeronautics program. The follow-on activities emanating from Phase 1 which are of mutual interest to both NASA and DOT will be jointly funded by the two agencies, and those tasks of sole interest to each agency will be independently funded.

Aeronautics Systems Technology Programs

W76-70170 **510-51-01**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATION TO THE C-130 CENTER WING STRUCTURE
R. R. Heldenfels 804-827-2042
(505-02-41)

The objective of this program is to obtain longtime flight service performance of filamentary composite materials in the center wing box of C-130 aircraft. The objective will be achieved through a systematic program as follows: (1) conduct advanced development study to provide design allowables, manufacturing and process methods, required analysis methods; (2) perform detailed design; (3) fabricate three composite-reinforced aluminum-alloy wing boxes; (4) perform ground test on one full-scale box (fatigue and strength); (5) install wing boxes in two C-130 aircraft, and deliver aircraft to Air Force; and (6) perform periodic monitoring to establish performance of wing boxes. The results of this flight service program will provide meaningful data on the performance of composite materials in a primary structure in the flight environment. Results will also be obtained on design, manufacturing and processing methods, nondestructive evaluation and field inspection procedures heretofore unavailable on large scale composite-reinforced primary aircraft structures. The program will provide confidence needed before commitments are made to future applications in aircraft structures.

W76-70171 **510-52-01**
Langley Research Center, Langley Station, Va.
COMPOSITE PRIMARY STRUCTURES FLIGHT PROGRAM
R. R. Heldenfels 804-827-2042
(505-02-41; 510-51-01)

The objective is to establish a confidence level and economic base for filamentary composite primary structures that will warrant a production commitment by airframe manufacturers to incorporate these structures in future commercial transport aircraft. This objective will be accomplished by demonstrating weight savings of about 25 percent with composite materials, by accumulating operation and maintenance experience in an airline environment, and by developing the design and manufacturing technology required to lower the acquisition cost of composite primary structure as well as to achieve life-cycle costs comparable to current metal aircraft structure. The flight components will be replacement parts on existing commercially operated aircraft.

W76-70172 **510-53-01**
Lewis Research Center, Cleveland, Ohio.
MATERIALS FOR ADVANCED TURBINE ENGINES (MATE)
N. T. Saunders 216-433-4000
(505-01-12)

This program involves the application of at least five new materials and manufacturing processes for aircraft turbine engines planned for the 1980-85 time-frame. It will cover the advanced development, rig, and engine testing necessary to demonstrate the potential of new materials technology for use in future engines. The purpose of this program is to accelerate the application of new materials technologies to aircraft engine use in order to achieve improved engine performance benefits. The program will be conducted through contracts with domestic engine manufacturers and their vendors. New materials and processes that have shown laboratory feasibility in exploratory development programs will be selected for further development and evaluation under this program. Cost/benefit and risk analyses will be conducted to help guide the selection of the best candidate materials. The selected materials will then be scaled-up, manufactured into appropriate engine hardware, extensively evaluated to provide preliminary design data, and tested in both engine-simulation rigs and experimental engines to demonstrate their potential for future engine use.

W76-70173 **510-54-01**
Langley Research Center, Langley Station, Va.
INTEGRATED PROGRAMS FOR AEROSPACE-VEHICLE DESIGN (IPAD)
R. R. Heldenfels 804-827-2042

The objective is to reduce vehicle design cycle time by 50 percent and design costs by 25 percent by 1980 through development of a computer-aided design system for industry. Statement of Work is complete incorporating results of Boeing and General Dynamics IPAD Feasibility Studies, critiques of those studies, and a missile system design application study. Industry interface approach has been formulated and summarized in a Prospectus disseminated to industry for their feedback. Industrial development will be undertaken with a prime contractor if industry reaction to Prospectus if favorable. In-house work will be aimed at preparing the IPAD Development Section to monitor the contractor to ensure development of software which will improve the productivity of the U. S. aerospace industry.

W76-70174 **510-55-01**
Lewis Research Center, Cleveland, Ohio.
AEROELASTICITY OF TURBINE ENGINES
R. H. Kemp 216-433-4000

The overall objective of this area of research is to evolve improved empirical flutter boundary criteria and to obtain information concerning the factors that influence these criteria. Also, to provide, through analytical and experimental research, a more scientific basis for the reliable prediction and avoidance of instability regions. A program plan has been evolved by a joint NASA-LeRC/USAF-APL panel that was established in December 1973. The work outlined by this RTOP document is based on the deliberations of that panel and reflects the areas of responsibility recommended by the panel to LeRC. The LeRC program contains a number of related elements covering nonsteady aerodynamics, structural dynamics, coupling analyses, and experimental flutter boundary data collection and correlation. In-house theoretical and experimental studies will be complemented by contractual work to take advantage of special existing flutter research facilities and capabilities.

W76-70175 **510-56-01**
Ames Research Center, Moffett Field, Calif.
FIRE-RESISTANT MATERIALS ENGINEERING
D. R. Chapman 415-965-5065
(505-01-31; 505-08-21)

The objectives are: (1) to accelerate the transfer of advanced materials and structures technologies to application in design of fire safe airframe structures and aircraft interiors; and (2) to provide the technology base required for the airframe manufacturers to make future aircraft materials, structures and subsystems as fire-resistant as feasible in order to provide an increased probability of passenger and crew survivability in aircraft interior and exterior fires. Fire-resistant materials and fire control systems will be evaluated for application to aircraft interiors and fuselage. Tests will be conducted to assess the fire threat levels that state of the art materials and aircraft structures can withstand. The limit of the degree of fire-hardening for state of the art aircraft structures will be established. Initially, tests will be conducted on unattended areas of aircraft such as lavatories, cargo bays, and other aircraft interior sections retrofitted with state of the art materials. Following these tests improved fire-resistant materials will be utilized to construct those systems which subsequently will be evaluated to determine the degree of fire-hardening. This program will be conducted in cooperation with the Johnson Space Center.

W76-70176 **511-51-01**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MULTISTAGE AXIAL FLOW COMPRESSOR
M. J. Hartmann 216-433-4000
(505-04-21)

Compressors for advanced military and commercial aircraft must be lightweight and efficient and capable of operating over a wide range of conditions. Hardware, maintenance, and operational costs and fuel consumption must all be reduced below present levels. Besides achieving high component performance levels the compressor must be selected to be compatible with expected advancements in the related technology areas of materials, structures, acoustics, fans, combustors, turbines, controls, bearings and seals. To meet these requirements high pressure stages must be properly matched in a multistage compressor operating at high rotational speeds. The compressor is the pacing item in advanced engine development programs. From program risk and schedule considerations, it is necessary to select a compressor design that has demonstrated suitable performance or to minimize modifications to such compressors. To provide an advanced compressor utilizing high levels of stage pressure ratio, the performance of a multistage compressor designed for an overall pressure ratio in the range of 15:1 to 20:1 will be determined. A preliminary design and definition study will investigate compressors having from six to twelve stages and having overall pressure ratios of 15:1 to 20:1. The compressor indicated in the preliminary study as providing the greatest benefit to advanced transport aircraft of the mid 1980's will be built and tested at the contractor's site.

W76-70177 **511-53-01**
Lewis Research Center, Cleveland, Ohio.
QUIET, CLEAN GENERAL AVIATION TURBOFAN (QCGAT)
G. K. Sievers 216-433-4000
(505-03-12)

An experimental program is planned to provide the technology for quiet, clean and economical general aviation turbofan engines. The program will utilize an existing general aviation turbojet or turbofan core in an experimental quiet high bypass turbofan engine. The experimental engine will incorporate the latest quiet engine technology derived from the Quiet Engine program, the Quiet Clean Short-haul Experimental Engine program and other related component technology programs. The approach to be used for noise reduction will be primarily directed toward the reduction of source noise by the use of such techniques as a high bypass ratio fan plus fan and turbine noise reduction techniques in preference to the use of extensive noise suppression systems. Three study contracts will be awarded to three small turbofan engine manufacturers to provide NASA with information required to start an experimental engine program (QCGAT). A single contractor will then be competitively selected for the experimental program which consists of design, fabrication, assembly and ground tests of an experimental turbofan engine.

W76-70178 **512-51-01**
Flight Research Center, Edwards, Calif.
DIGITAL FLY-BY-WIRE FLIGHT EXPERIMENT
C. R. Jarvis 805-258-3311
(512-51-02)

The overall objective of this effort with LaRC is to provide the technology necessary for the implementation of advanced reliable Digital Fly-By-Wire systems in future aircraft. Negotiations have been made with JSC to include as an additional objective; flight-test verification of key space shuttle flight control system software, hardware, and redundancy management concepts. The program is to be carried out in accordance with the schedules and resources identified by the Digital Fly-By-Wire project plan (revised yearly). The Phase 1 flight-test program to establish Digital Fly-By-Wire systems feasibility has been completed. In Phase 2, a multichannel digital system is to be developed and flight tested in the F-8C aircraft. This will be a three-channel system utilizing redundancy management concepts developed for space shuttle application and providing the capability to evaluate, in flight, advanced control laws being developed by LaRC.

W76-70179 **512-51-02**
Langley Research Center, Langley Station, Va.
DIGITAL FLY-BY-WIRE FLIGHT EXPERIMENT
J. E. Stitt 804-827-3745
(512-51-01; 505-07-31)

The objective of this effort is to provide a design base for reliable, cost-effective digital fly-by-wire flight control systems for commercial and military aircraft applications. A cooperative program of theoretical and experimental research and demonstration in DFBW flight control will be carried out by the Flight Research Center and the Langley Research Center. As presently conceived this program has two phases, phase 1 of which is an initial demonstration and exploration program using Apollo hardware. This program is complete. Responsibility for this program lay with FRC. Experimentation in control law software will take place during phase 2. The phase 2 program, in addition to experimentation in advanced control laws will involve researches into redundancy management of sensor systems that will benefit the flight control task.

W76-70180 **512-52-01**
Ames Research Center, Moffett Field, Calif.
GENERAL AVIATION - ADVANCED AVIONICS SYSTEM
C. Thomas Snyder 415-965-5427

The overall objective of this program is to provide the critical information required for the design of a reliable low-cost avionics system applicable to General Aviation aircraft which would enhance the safety and utility of this mode of transportation. Sufficient data will be accumulated upon which industry can base the design of a reasonably priced system having the capability required by General Aviation in and beyond the 1980's. It should also be emphasized that this program is directed at establishing the technology for a total avionics systems design (i.e., navigation, guidance, control, powerplant management, displays, etc.) as opposed to singling out a particular subsystem, or function, upon which the research effort will be concentrated. The program will include: analysis, system concept studies, piloted simulation and component research and development. Throughout the program, active coordination will be maintained with the DOT-FAA. It is recognized that an essential ingredient in this program is the strong and direct participation of the General Aviation industry and its representatives.

W76-70181 **512-52-02**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION ADVANCED AVIONICS
J. E. Stitt 804-827-3745
(505-07-12; 505-07-22; 513-05-51)

This effort will develop and apply advanced avionics and fluidics technology to the instrumentation and control of general aviation aircraft. Emphasis will be directed toward the light aircraft end of the general aviation spectrum, which comprises about 85% of the G. A. aircraft. For this reason, low cost and low maintenance (high reliability) will be primary drivers in this program. Evolving technology such as fluidics, special purpose integrated circuits, and low-cost microprocessors will be investigated for use in avionics and control systems for light G. A. aircraft. Subsystem and component designs will be made to evaluate the new technologies, and to provide examples of the avionics and controls capabilities. These designs will be aimed at providing increased capabilities for the relatively inexperienced pilot without significantly effecting his workload, particularly in planned or unplanned operations under adverse weather conditions. In the controls area, fluidics work previously under 505-07-23 will be continued to expand the technology of no-moving-parts autopilots. Also, stall-warning/control sensors and systems will be developed. The avionics work will develop an inexpensive moving-map display, and matrix display concepts.

W76-70182 **512-53-01**
Langley Research Center, Langley Station, Va.
ACTIVE CONTROL AIRCRAFT FLIGHT EXPERIMENT
J. E. Stitt 804-827-3745
(512-53-02)

The objectives are to identify, develop and validate technology required to establish design guidelines for the incorporation of active controls in future civil aircraft and to demonstrate this technology using a special flight research vehicle. This will result in aircraft with improved economics, performance and ride qualities while being safer to operate. The approach is to (1) validate active control technology by direct comparisons of theoretical

and wind tunnel and flight experimental results, (2) provide missing data needed for the design of active control systems, (3) develop computer programs to be used in integrated conceptual design studies, (4) establish the benefits of using active control systems, through integrated conceptual design studies, and (5) demonstrate the application of active controls using a special research vehicle.

W76-70183 **512-53-02**
Ames Research Center, Moffett Field, Calif.
ACTIVE CONTROL AIRCRAFT FLIGHT EXPERIMENT
C. Thomas Snyder 415-965-5444
(512-53-01; 512-53-03; 505-07-11)

The objective is to apply Active Control Technology (ACT) to short haul, turboprop, STOL, and VTOL aircraft to assess potential performance, fuel savings, and passenger acceptance benefits, identify technology requirements, provide a test bed for verification and application of technology, and provide a data base on which design criteria for these aircraft can be developed. Provide a proven methodology to apply advanced control concepts to these aircraft, with attention to aircraft and control system modeling, simulation, testing hardware development and flight verification of systems. Develop a data base for nonpowered-lift and power-lift aircraft which will include economic justification, technical feasibility, ride control, gust load alleviation, aircraft handling qualities, effects of failure modes on controllability, redundancy requirements, ATC coupled systems, and interactions of these concepts. The approach will be to integrate the relevant computer programs used in aerodynamics, structure, propulsion, control and economics into a single interdisciplinary active control system design program that is applicable at any state in the aircraft design cycle. The design program will be evaluated by simulation and flight test using a DHC-6 turboprop aircraft with modified control surfaces. A conceptual design of an optimally ACT-configured short-haul, nonpowered-lift transport will be developed and evaluated. In addition, design methodology for total active control systems for powered-lift STOL and VTOL aircraft will be developed. This design methodology will be evaluated by simulation.

W76-70184 **512-53-03**
Flight Research Center, Edwards, Calif.
ACTIVE CONTROLS AIRCRAFT FLIGHT EXPERIMENT
D. A. Deets 805-258-3311
(512-53-01)

A coordinated program is planned in conjunction with the Active Controls Aircraft Program to supplement, validate, and demonstrate the design techniques required to incorporate active control into the design of future civil aircraft. The specific FRC objectives include: (1) design and test simple aeroelastic wind-tunnel models and RPRV flight test models to demonstrate flutter suppression concepts as they are developed; (2) conduct studies to determine the most effective means for demonstrating and transferring active controls technology to industry; and (3) conduct flight demonstration tests of a special ACA research vehicle. Theoretical and wind tunnel work will be performed under research grants. Studies and fabrication of demonstrator will be done by contractor.

W76-70185 **513-50-50**
Langley Research Center, Langley Station, Va.
TRAVELER ACCEPTANCE - LOW DENSITY SHORT-HAUL SYSTEMS
R. E. Bower 804-827-3285
(504-09-21)

The objective is to identify, study in detail, and model those factors influencing acceptance and use of aircraft as the preferred mode of travel by the public in the low- to medium-density short-haul market. Appropriate information will be compiled through literature search, traveler questionnaires, and measurements aboard low- to medium-density, short-haul airline systems. Limited information will also be obtained concerning competing modes of transportation which could influence choice of travel mode. The data will be analyzed and mathematically modeled. Some existing types of aircraft used in low-density, short-haul service will be evaluated using this model. The majority of effort will be carried out under grant.

W76-70186 **513-50-51**
Langley Research Center, Langley Station, Va.
VLF WIDE AREA NAVIGATION FOR LOW-DENSITY SHORT-HAUL TRANSPORTATION
J. E. Stitt 804-827-3745
(505-07-12)

The objective of this work is to investigate VLF navigation techniques and to develop promising approaches for en-route and terminal area navigation. Systems such as Omega can provide large geographic coverage with a limited number of ground stations, and are relatively unaffected by altitude or terrain. Characteristics such as these are highly desirable for short-haul, low-density transportation systems, where direct terminal-to-terminal routes at relatively low altitudes are required. The application of VLF navigation to civil aviation will also enhance air safety by reducing pilot navigating within a network of approximately 1000 VOR stations. Work will be conducted in two areas. The first area consists of the measurement and analysis of errors due to propagation anomalies and atmospheric noise. The second area consists of the development and evaluation of Omega avionics, including both differential and composite Omega configurations.

W76-70187 **513-50-53**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF THE OPERATIONAL COMPATIBILITY OF FUTURE CIVIL AIR TRANSPORTATION AND CONCEPTS
T. L. Galloway 415-965-5887
(513-50-52; 513-50-53)

The objective of this RTOP is to provide analyses of new civil air transportation system operational concepts and procedures that will result in improved airport functions and reduced congestion, increased safety, and improved air traffic control. Specifically, the study of the design, the operation and potential market for future medium density transports will be continued along with studies of the effect of microwave landing systems on airport capacity and short haul transportation system turn-around times. In addition, studies of future airport concepts will be initiated. These studies will be performed both in-house and under contract. Close coordination will be maintained with the Department of Transportation on each of these studies.

W76-70188 **513-50-54**
Ames Research Center, Moffett Field, Calif.
FEASIBILITY AND VALIDATION OF LOW COST MICROWAVE LANDING SYSTEM AVIONICS
C. Thomas Snyder 415-965-5488
(513-53-02; 513-53-03; 512-52-01)

The overall objective is to support the FAA in implementing the National Microwave Landing System (MLS) Program by validating the feasibility of low cost airborne MLS avionics. Specific objectives include establishing the operational/functional requirements and specifications for a low cost MLS receiver; designing, constructing and testing selected subassemblies that have the greatest potential for reducing receiver cost; assessing low cost receiver performance by integrating the individual subassemblies into a functional receiver; flight validating the avionics feasibility model performance with two or more MLS ground stations of widely differing degrees of complexity for application to low density STOL and small community business and general aviation operations; and producing a detailed final report for distribution to the FAA and avionics/MLS manufacturers. The basic approach is to accurately define the required low cost MLS receiver performance specifications, identify the cost critical receiver subassemblies, design and construct brassboard models of those selected subassemblies with the primary emphasis on reducing cost and establishing a design-to-cost figure, integrate the subassemblies into a feasibility model MLS receiver and perform a flight test validation of the airborne avionics. Refined cost projections will be obtained after hardware optimizations are made. These optimizations will assume volume fabrication and production techniques and a quantity standard of 1000 units. Cost reduction of operational MLS avionics developed through this program will be the primary measure of program effectiveness.

W76-70189 **513-52-01**
Langley Research Center, Langley Station, Va.
TERMINAL CONFIGURED VEHICLE PROGRAM
J. E. Stitt 804-827-3745
(505-07-31)

The Terminal Configured Vehicle (TCV) Program is an advanced technology activity focused on Conventional Take-Off and Landing (CTOL) Transport Aircraft that will be operating in reduced weather minima in the future high-density terminal areas equipped with new landing systems, navigational aids, and increased surveillance and automation under development by DOT/FAA. The broad objectives of the Program are to provide improvements in the airborne systems (avionics and air vehicle) and operational flight procedures for reducing approach and landing accidents, reducing weather minima, increasing air traffic controller productivity and airport and airway capacity, saving fuel by more efficient terminal area operations, and reducing community noise by operational procedures. This involves research analyses, simulations, and flight studies. A modified Boeing 737 airplane, (Research Support Flight System, RSFS), equipped with highly flexible display and control equipment being made available by DOT/FAA, will be used to study operations in simulated future terminal area environments. Active coordination will be maintained with DOT/FAA and DOD. Particular emphasis will be given to compatibility with the microwave landing system (MLS) under development by DOT/FAA and with future air traffic control systems. CTOL transport, terminal area, productivity, capacity, fuel saving, MLS, reduce noise, acceptance rates, air traffic control, reduce runway occupancy.

W76-70190 **513-53-01**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY FOR ADVANCED INTEGRATED AVIONICS FOR TERMINAL AREA FLIGHT EXPERIMENTS IN STOL AIRCRAFT
C. T. Snyder 415-965-6383
(513-53-02; 513-53-03)

The objective is to develop navigation, guidance, and control avionics for use in STOL flight experiments and for use in STOL validation flights for the new common-use civil/military Microwave Landing System (MLS). The potential advantages of STOL can be realized only with advanced avionics systems and associated operational procedures which exploit the capabilities of STOL for making steep ascents and descent, tight turns, and slowspeed approaches and landings within the constraints of proposed ATC systems. Performance and design requirements for a flexible avionics system which will operate in various manual and automatic modes will be defined to satisfy the objectives of STOL flight experiments and of STOL MLS validating flights. In particular, requirements will be based on the use of the developmental scanning beam system, MODILS, (and perhaps the MLS) provided by the FAA for use in the STOL flight experiments. The flexible avionics system referred to as STOLAND will be designed and developed and then installed in appropriate STOL aircraft and tested in flight. With the exception of MODILS/MLS, the flight tests will be conducted using standard instrumentation, tracking, data processing, and navigation aids. The detailed design and development of STOLAND, which will be performed by the contractor, will be supported by relatively complete fixed base and moving base simulations of the aircraft and avionics system at Ames Research Center.

W76-70191 **513-53-02**
Ames Research Center, Moffett Field, Calif.
MICROWAVE LANDING SYSTEM VALIDATION FOR STOL AIRCRAFT APPLICATIONS
C. Thomas Snyder 415-965-5488
(513-53-01; 513-50-54)

The overall objective is to assist the FAA in developing the Microwave Landing System (MLS). Specific objectives include the refinement of the MLS operational/functional requirements for STOL operations; assisting the FAA in developing the prototype MLS configurations and specifications; establishing the MLS/STOL evaluation criteria and procedures; and evaluating a prototype basic configuration MLS for STOL operations. The basic approach is to utilize analysis, piloted and computer simulations, and the results of the STOL Operating Systems Experiments to refine the MLS operational requirements and evaluation criteria for STOL operations. The results of the MLS Feasibility tests, the MLS Technique Selection Process, and the STOL Experiments will be incorporated into this evaluation. The above facilities will also be used to refine the prototype MLS accuracy specifications. The suitability of the MLS for STOL applications will be evaluated utilizing representative STOL aircraft, the experimental STOLAND avionics system, and a prototype basic configuration MLS.

W76-70192 **513-53-03**
Ames Research Center, Moffett Field, Calif.
STOL OPERATING SYSTEMS EXPERIMENTS USING MODELS AND THE CIVIL MILITARY MICROWAVE LANDING SYSTEM (MLS)
C. Thomas Snyder 415-965-5424
(513-53-01)

Experiments will be conducted on navigation, guidance, control, and flight management systems for STOL aircraft using advanced airborne avionics and a Microwave Landing System. The results will be used to evaluate system concepts and define design criteria and operational procedures for STOL aircraft. This program is part of the Joint DOT/NASA Operating Systems Experiments Program. Investigations will be conducted encompassing analysis, simulation, flight experiments, and supporting studies. These investigations will emphasize the terminal area navigation, guidance, control and flight management problems which must be solved to take maximum advantage of STOL capabilities for making steep ascents and descents, tight turns, and slow speed approaches and landings. The flight experiments will be conducted using a flexible research avionics system, referred to as STOLAND, in conjunction with appropriate STOL aircraft. The complete research system comprises STOL aircraft, avionics system, instrumentation, and the following navigation aids: VOR/DME, TACAN, and a microwave landing guidance system to be provided by the FAA.

W76-70193 **513-53-05**
Ames Research Center, Moffett Field, Calif.
INVESTIGATION OF THE USE OF STRAPDOWN INERTIAL SENSOR UNITS FOR THE INTEGRATION OF FLIGHT CONTROL, GUIDANCE AND NAVIGATION FUNCTIONS.
C. Thomas Snyder 415-965-5983

The objective is to research in-flight investigation of specific strapdown sensor systems for a lowest cost, highly-reliable inertial guidance and control concept which can be used as an integrated sensor package, and for use in improving navigation. This system will make full use of digital computer technology with the system elements regrouped for maximum performance and minimum complexity and cost. It will be a redundant system which utilizes an aircraft control computer for navigation, guidance and flight control. A candidate system with ring laser gyros is being developed by ARC which will replace all the standard set of inertial sensors with a tetrad strapdown inertial reference system configuration. There are four tasks in this program. Task 1 is the establishment of requirements, identification of applicable technology, and the configuring of ARC prototype flight systems. Task 2 is the identification of system performance and the fabrication of the ARC prototype strapdown inertial reference systems. Task 3 comprises the investigation of these systems through a simulation, laboratory test, and flight test program. It includes the development of Kalman filters for tetrad redundancy management and inertial smoothing for radio navigation. Task 4 is the utilization of radio signals for aiding the prototype ARC Ring Laser Gyro Tetrad strapdown system when performing the short haul aircraft guidance and control missions.

W76-70194 **513-53-06**
Ames Research Center, Moffett Field, Calif.
TERMINAL AREA EFFECTIVENESS PROGRAM - OPTIMIZATION OF FLIGHT PROCEDURES OF SHORT HAUL TRANSPORT AIRCRAFT
C. T. Snyder 415-965-5567
(505-10-34)

The overall objective of the program is to provide guidance

to NASA's aeronautical research and technology efforts by developing techniques and facilities for determining and improving the effectiveness of future short-haul air transportation. The criteria for effectiveness will include such factors as fuel usage, noise and pollution impact, terminal area capacity, ride quality, airspace and ground space usage, pilot acceptance, operating economics, etc. Special emphasis is placed on the terminal area although certain criteria must be considered over the entire mission for meaningful results. Mathematical models required for effectiveness studies will be developed for future short-haul transport aircraft, their noise and energy usage characteristics, and for the future air traffic environment as well as for other elements of the short-haul system. These models will be used in fast and real time simulations to develop optimum flight procedures. System studies will be conducted to determine the capacity of future terminal areas as a function of implementation alternatives. A methodology will be developed for integrating the effectiveness measures in order to obtain a total assessment of terminal area effectiveness. A terminal area simulation consisting of a piloted simulation at Ames and a FAA-NAFEC directed ATC simulation will be conducted to validate the procedures and systems resulting from the effectiveness evaluation studies.

W76-70195 **513-54-01**
Ames Research Center, Moffett Field, Calif.
VTOL OPERATING SYSTEMS EXPERIMENTS
C. Thomas Snyder 415-965-5569
(513-53-01; 513-53-03)

The objective is to develop a data base for use in establishing system concepts, design criteria, and operational procedures for VTOL aircraft. This technology base will aid the development of efficient, economical VTOL short-haul operations with minimum adverse environmental impact. The objective also includes a research and technology program to support military requirements for assuring a VTOL operational capability into a wide variety of landing sites, under reduced visibility conditions. The approach will utilize: analytical studies, piloted closed-loop simulations, and flight experiments. Analytical studies will be carried out in-house and under contract. Piloted simulation studies will be accomplished at Ames prior to flight tests. Flight experiments will be carried out in the Tilt Rotor Research Aircraft (XV-15) using V/STOLAND. Two avionics systems (V/STOLAND) will be procured. The first system will be installed in a fixed-base simulator at Ames for development of computer software programming and piloted simulation studies. This system will then be checked out in an Army UH-1 prior to installation of the second system in the XV-15. The XV-15, with avionics system, will be used to investigate alternative avionics functional configurations, flight paths, operational procedures, levels of automation, and landing aids. Time constrained flight paths, steep curved, decelerating, and omnidirectional approaches, and the effects of winds will be investigated. This RTOP describes the NASA tasks in a joint program with the Army. The systems will be also used by the Army for simulation and flight investigations of tactical helicopter missions not described herein. Joint funding is shown.

W76-70196 **513-54-02**
Langley Research Center, Langley Station, Va.
ROTARY WING VTOL OPERATING SYSTEMS EXPERIMENTS
J. E. Stitt 804-827-3745
(505-10-23; 505-10-24; 505-07-41)

The program will encompass the investigation of operating systems and piloting techniques for operations from downtown vertiports under all-weather conditions. Terminal air traffic procedures, airspace requirements, the avionics system requirement for navigation, guidance, flight control, and displays for takeoffs, cruise and landing will be defined. Flight vehicles and simulation facilities equipped with electronic display systems and advanced control concepts will be used to define the degree of automation required in the aircraft control system and in the guidance, display, and communication systems onboard the aircraft for VTOL terminal-area operations. Operating procedures and piloting techniques for curved, decelerating approach trajectories will be explored for application to steep-gradient operations into congested areas. As part of the joint NASA/Army program in which a CH-47 is being provided, studies will be made of pilot cueing requirements for improved handling qualities, warning for critical envelope limits and for aiding the pilot in interfacing with the automated or partially automated control systems.

W76-70197 **513-54-03**
Langley Research Center, Langley Station, Va.
HELICOPTER - AIR TRAFFIC CONTROL INTEGRATION STUDY
J. E. Stitt 804-827-3745
(505-10-23; 514-53-02)

This research is concerned with the problems of integrating V/STOL aircraft and their air traffic control system into the total air traffic control environment of the terminal area. The objectives are to determine: (1) aircraft design and equipment requirements; (2) operating procedures and airspace volumes; (3) ATC equipment and handling procedures, and (4) requirements for compatibility and integration of the V/STOL system with the total ATC complex. Real-time simulations are being conducted of a VTOL aircraft operating in metropolitan areas and performing precision approaches at high-density airports. These simulations will be improved to include new terminal-area routings and approach concepts based on the low-speed and maneuver capabilities of V/STOL configurations. Increased reality will be obtained by linking the Langley simulator with the FAA's ATC simulator at Atlantic City, followed by the eventual linking of a V/STOL aircraft operating at the Wallops Radar Flight Facility and being provided simulated total terminal-area traffic environment by linking to the Atlantic City ATC simulator.

W76-70198 **514-50-01**
Ames Research Center, Moffett Field, Calif.
ADVANCED V/STOL AIRCRAFT DESIGN AND APPLICATION STUDIES
W. L. Cook 415-965-5559
(505-10-35; 744-01-01; 769-02-02)

The objective of this effort is to investigate advances in V/STOL aircraft technology which offer unique performance and operational advantages for civil and military application. Aircraft design and application studies will be performed to support technology development programs for advanced V/STOL aircraft, and to provide guidance to the planning and conduct of related OAST research programs. Potential applications of lift fan, tilt rotor, and advanced helicopter aircraft to a wide range of civil utility missions are currently being studied under contract. Those applications which can best exploit the capabilities of V/STOL and lead to significant improvements in mission effectiveness will be identified by matching aircraft performance characteristics to mission requirements. Design Studies of a gust alleviation system for the XV-15 tilt rotor research aircraft utilizing composite blade hingeless rotor with integrated rotor/flap/aileron feedback controls will be initiated. These studies will provide preliminary estimates of system gains, authority and control rates for follow-on wind tunnel investigations. This design study will use existing computer programs modified for this particular study and the Ames turbulence math model for simulation. Conceptual design studies of tilt rotor commercial transport aircraft having telescopic (TRAC) rotors will be performed. These studies will provide an assessment of weight penalties, performance gains, fuel efficiency, DOC and noise. Rotor design and wind tunnel test requirements will be determined.

W76-70199 **514-52-01**
Ames Research Center, Moffett Field, Calif.
WAKE VORTEX MINIMIZATION
C. T. Snyder 415-965-5567
(505-08-22)

Short and long range aerodynamic solutions to the aircraft trailing vortices will be obtained. Investigations will be made to determine: (1) the fundamental mechanisms involved in vortex generation and decay; (2) the components of vortex velocity, turbulence, and the rolling moment on a following aircraft up to large distances behind the aircraft for various conditions of angle of attack, flap deflection, stabilizer incidence, etc., and (3) vortex dissipation resulting from variations in span loading and turbulence at the generating aircraft. Both theoretical studies

and experimental investigations utilizing wind tunnels and water tow facilities will be made. Promising vortex alleviation concepts will be applied to specific transport aircraft and evaluated in flight.

W76-70200 **514-52-01**
Flight Research Center, Edwards, Calif.
WAKE VORTEX MINIMIZATION FLIGHT EXPERIMENTS
Larry C. Montoya 805-258-3311
(505-06-22)

This RTOP covers FRC activities related to full-scale flight-test evaluations of various aerodynamic wake vortex alleviation devices. These devices have been, and/or, are being developed in ground facility test under the related RTOP (505-06-22). The approach taken will be that of flight testing the devices on actual transport aircraft (e.g., 747's, 727's, L-1011's, etc.). Comparisons of the vortex characteristics with and without the devices will be made by probing the aircraft's wake with specially instrumented probe aircraft (e.g. FRC's T-37 and ARC's Lear Jet). To facilitate wake probing and visual determinations of vortex breakdown characteristics an improved vortex visualization system will be developed. This development of an improved vortex visualization system will provide information relevent to the related RTOP (505-08-1X). The persistent nature of trailing vortices generated by jet transports create a documented safety hazard for following aircraft. This hazard severely curtails optimum use of our nations airports. The FAA's present solution to this problem (increase separation distances to 3 to 5 miles) is not satisfactory because it results in a greatly reduced runway utilization rate.

W76-70201 **514-52-01**
Langley Research Center, Langley Station, Va.
WAKE VORTEX MINIMIZATION FLIGHT RESEARCH
R. E. Bower 804-827-3285
(505-08-22)

The objective is to develop and demonstrate wake vortex minimization methods and devices acceptable for routine aircraft operations. Laboratory and flight tests have established the feasibility of modifying the trailing vortex system of an aircraft by aerodynamic means. Laboratory testing will continue to develop alleviation means that will allow safe and economic operation of aircraft with separation distances of two nautical miles. Flight evaluations will be conducted as required to demonstrate the effectiveness and operational suitability of the alleviation methods and devices.

W76-70202 **514-52-02**
Ames Research Center, Moffett Field, Calif.
NUMERICAL SIMULATION OF VORTEX WAKES
Harvard Lomax 415-965-5124
(505-06-12)

The objective is to develop a computer code that can be used to calculate the flow behind an airplane in the takeoff and landing condition. A primary purpose is to simulate the effects of vortical turbulence that arises from landing gear, flaps, nacelles and other protuberances that disturb the flow in the wake of a large airplane. The codes will be used to study the sensitivity of wake flow to changes in airplane configuration, flap deflection and wing loading, in general. The three-dimensional Navier-Stokes equations with an eddy viscosity will be used as the governing equations. They will be solved numerically to find the time history of the vorticity generated behind an airplane traveling at a low Mach number. At least two codes will be developed, one in a Lagrangian, vortex-tracing frame and the other in a fixed Eulerian mesh. The initial study will involve relatively simple vortex interactions so that the codes can be tested and verified both against one another and with experiment.

W76-70203 **514-53-01**
Langley Research Center, Langley Station, Va.
ROTOR SYSTEMS FOR ROTOR SYSTEMS RESEARCH AIRCRAFT
R. E. Bower 804-827-3285
(505-10-21)

In order to insure timely rotorcraft technology development and demonstration and to provide maximum efficiency of utilization of the Rotor Systems Research Aircraft (RSRA), research rotor systems will be selected, designed, fabricated, and flight tested. A technology program for hardware development and flight experiments will be defined for testing of current and advanced technology rotor systems through a broader flight envelope to define and document technological advancements for rotors and rotorcraft. Through a series of advanced systems design study contracts initiated in FY-1975, definitive program plans are being developed in order to establish both technical and budgetary data necessary for initiating the initial major rotor system design and fabrication in FY-1976. Parallel effort will be continued to provide the design verification information required for both the variable geometry rotor and the composite structure rotor. Predesign studies leading to definition of effective manufacturing techniques for the aero/acoustic rotor are also being carried out.

W76-70204 **514-54-21**
Flight Research Center, Edwards, Calif.
F-15 FLIGHT RESEARCH PROGRAM
Adkins J. 805-258-3311

The objectives of this effort are: (1) assess F-15 high alpha and agility, including stall/spin, flying characteristics and compare with other experimental data; (2) assess F-15 engine/inlet compatibility, particularly at higher alpha, and compare with other experimental data; (3) assess F-15 airframe/propulsion system interference (boattail drag) and correlate with other experimental data; (4) assess the flight suitability of integrated digital propulsion system controls on the F-15 and correlate with other experimental data; and (5) support the USAF in determining the acceptability of F-15 product improvement items. This will be a joint USAF/NASA Intercenter effort with flight activity being conducted at FRC in accordance with a Memorandum of Understanding which will be negotiated with the USAF. NASA unique flight activities will be fully funded by NASA under this RTOP. USAF unique activities will be fully funded by the USAF. The USAF is expected to administer all NASA contracts which involve the USAF Contractors for the F-15 and its systems. NASA will maintain and operate the airplane and its systems and will provide funding for on-site contractor support of the flight activity. The USAF is expected to allow NASA reimbursable access to the F-15 logistics system for spare parts and component repair and to assign a high priority to this logistic support of the program.

W76-70205 **515-51-11**
Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS IN APPROACH AND LANDING SAFETY
H. P. Klein 415-965-5094
(504-09-32; 505-08-23)

The objectives are: (1) to provide objective information regarding factors in the aviation system which cause or contribute to the occurrence of human errors in air transport operations, especially during the approach and landing phases of flight; (2) to evaluate the potential dangers posed by these factors in aviation operations; (3) to examine ways of eliminating such factors from the aviation system, or of minimizing their potentially harmful effects; and (4) to reduce the incidence of approach and landing accidents caused by or attributed to human errors. The approach is to do (1) descriptive and analytic studies of occurrences, incidents and accidents to determine system and other factors which are associated with human errors in air transport operations; (2) full-mission simulation studies to evaluate the ways in which these factors influence human performance; (3) evaluation in simulation or flight research of candidate solutions designed to eliminate or minimize the decremental effects of these factors; and (4) collaboration with government and industry groups in implementing promising solutions designed to reduce the number and seriousness of human errors in the aviation system.

W76-70206 **516-50-10**
Ames Research Center, Moffett Field, Calif.
OBLIQUE WINGED AIRCRAFT SYSTEM STUDIES
R. H. Petersen 415-965-5881

The objective of these studies is to provide configuration definition and detailed analysis in selected technical areas of oblique winged transport aircraft. Previous contract system studies identified promising high transonic speed, oblique winged aircraft at the conceptual design level. An ongoing study of FY-1975 will also identify a similar subsonic aircraft. Studies this year will provide technical and economic depth to the understanding of both the high transonic and the subsonic speed concepts. Contracts will be initiated to perform an assessment of the relative economics and energy consumption of oblique wing aircraft for subsonic and Mach = 1.2 flight and to perform an assessment of operational and practical application of oblique wing aircraft in an airline environment. Further studies will be initiated, in-house, to examine the potential for application of the oblique wing concept to high performance short-haul transport aircraft. The study of relative economic and energy characteristics will be a competitive 9 month contract ending in June 1976. The airline evaluation of oblique winged aircraft will be a competitive contract extending over a 6 month period ending in June 1976. Technical refinement of the subsonic concept will be an extension to the current contract, to be completed in a 6 month period ending in May 1976. Refinement of other key technical areas will be a competitive contract of 50K$ ending in September 1976.

W76-70207 **516-50-11**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY STUDIES OF AERONAUTICAL SYSTEMS
M. D. Ardema 415-965-5887

The objective of this work is to help develop a sound technological base for future decisions relating to the design, development, and operation of commercial transportation systems. This objective will be achieved through studies that examine the relationships between aircraft technology airline economics and markets, and environmental constraints. These studies will be done in sufficient detail to provide a realistic assessment of technical problems regarding transport aircraft design, development and operations and their development and operational costs. Study results will be used to help define the future direction of productive technical (and system related) activity for air transportation systems. This investigation will be performed in-house and under contract.

W76-70208 **516-50-20**
Langley Research Center, Langley Station, Va.
ADVANCED TRANSPORT SYSTEMS TECHNOLOGY STUDIES
R. E. Bower 804-827-3285
(791-40-01)

The objective is to perform systems and design integration studies for subsonic C/RTOL commercial transports in order to: (1) identify and quantitatively evaluate technology advances that will improve aircraft economics, fuel consumption, noise, emissions and terminal-area congestion; and (2) determine the technical and economic feasibility of utilizing other fuels in combination with JP fuel. In-house studies supplemented by contractor studies in critical areas will be performed for aircraft and secondary systems. Contractor capabilities will also be utilized to upgrade existing in-house vehicle design computer software.

W76-70209 **516-51-01**
Flight Research Center, Edwards, Calif.
YF-12 FLIGHT EXPERIMENTS
Gene J. Matranga 805-258-3311
(743-05-22; 743-01-21; 743-01-22; 743-01-23; 743-02-22)

The YF-12 type airplanes are the only airplanes in the free world which are capable of sustained Mach 3 flight. Major areas of research include the examination of the hot, flexible structure; dynamic inlet behavior; airframe/propulsion interaction; and general problems related to high speed and high altitude flight. In the structures area, thermocouples and strain gages have been installed in airplane 935. Ground calibrations will allow for the measurement of hot loads in flight. Flight results will be compared with NASTRAN predicted information. Dynamic inlet information obtained in flight will be compared with results from a 1/3 scale inlet model and a full scale inlet operated in the wind tunnel. Airframe/propulsion interaction flight information will be related to data predicted using a 1/12 scale airplane model. The airplanes will be used in support of numerous Supersonic Cruise Aircraft Research projects.

W76-70210 **516-51-02**
Lewis Research Center, Cleveland, Ohio.
YF-12 PROPULSION RESEARCH
M. O. Dustin 216-433-4000
(505-05-11)

The objectives are: (1) to evaluate the capability of currently available computer simulation techniques to determine the dynamic behavior of a high Mach number mixed compression inlet to downstream and upstream disturbances; (2) to determine the steady state and dynamic performance of a high Mach number, mixed compression inlet and compare the performance with a similar inlet in flight; and (3) to study existing aircraft control systems and investigate alternate techniques that minimize the propulsion system-airframe interaction.

W76-70211 **516-51-02**
Ames Research Center, Moffett Field, Calif.
YF-12 DISCIPLINARY RESEARCH
Richard H. Petersen 415-965-6010
(505-04-11)

The unique performance capabilities of the YF-12 airplane provide an opportunity to obtain heretofore unavailable flight data. These data are invaluable for the assessment of theoretical and empirical prediction methods. Comprehensive wind tunnel tests are being made in the areas of: (1) the engine-air inlet and internal flow system; (2) the effects on the aircraft aerodynamics produced by the various modes of operation of the propulsion system; and (3) aeroelastic effects on the aircraft stability characteristics. Flight tests will be conducted by the NASA Flight Research Center for correlation with the wind tunnel results, and with prediction based on theory. Current prediction techniques will be improved and resulting technology provided to industry for use in design of future supersonic cruise aircraft and an advanced YF-12 airplane to increase its Mach number and altitude capability.

W76-70212 **516-51-02**
Langley Research Center, Langley Station, Va.
YF-12 DISCIPLINARY RESEARCH
R. E. Bower 804-827-3285
(766-72-02; 766-72-02; 766-72-02)

The objectives are to evaluate analytical techniques for predicting boundary layer transition, heat transfer, and skin friction; to provide the basis for improved design prediction techniques; to define and provide solutions for unknown problems in flight, and to evaluate the application of experimental wind tunnel results to flight conditions. Approach will be to conduct pertinent ground-based analyses and wind-tunnel tests on a boundary layer test component (hollow cylinder 10 ft. long and 1.5 ft. in diameter) that will be flight tested on the YF-12 aircraft. Analyze and correlate these data with those from flight tests on the same component.

W76-70213 **516-53-01**
Langley Research Center, Langley Station, Va.
FUEL CONSERVATIVE AIRCRAFT SYSTEMS TECHNOLOGY
R. E. Bower 804-827-3285
(505-06-31; 791-40-08; 516-50-20)

The overall objectives are to develop advanced technologies that will lead to major savings in aircraft fuel consumption and to verify and demonstrate that the fuel conserving technologies are practical, economical, and safe for use on future transport aircraft. In-house ground-based experiments supplemented by contractor efforts will be performed to develop aerodynamic fuel conserving technologies. Aircraft systems studies, both in-house and contracted, will determine the most effective means of integrating these technologies and other fuel-saving technology for maximum fuel conservation consistent with ecological, economic, and operational considerations. As fuel conserving technology development progresses, limited flight experiments

will be performed to verify benefits and establish confidence in the technologies.

W76-70214 **516-54-01**
Langley Research Center, Langley Station, Va.
HYDROGEN-FUELED AIRCRAFT SYSTEMS TECHNOLOGY
R. E. Bower 804-827-3285

The objective is to provide a technology base in materials, structures, configurations, and tank systems to establish the feasibility and payoffs of liquid hydrogen fueled aircraft, and to determine the hazards and preventative measures which will permit a high degree of safety for hydrogen-fueled aircraft. The efficiency of various tank insulations suitable for use aboard aircraft, the compatibility of various metals with hydrogen and the fuel pump and distribution system for aircraft use will be established by the design and testing of subscale and, if required, full-scale experimental hardware. The approach is to perform in-house and contractual experimental studies of subscale cryogenic tank systems including lightweight insulations, and utilizing the most promising flight weight tank systems, perform experimental studies directed at application to aircraft design. Also, conduct configurational studies of liquid hydrogen aircraft concepts and carry out safety programs.

W76-70215 **516-55-01**
Lewis Research Center, Cleveland, Ohio.
VARIABLE CYCLE ENGINE COMPONENTS SYSTEMS TECHNOLOGY
E. A. Willis 216-433-4000

Modern high performance aircraft are required to operate over a wide variety of flight conditions. This creates conflicting requirements on the propulsion system which, in many cases, can be most effectively met by a Variable Cycle Engine (VCE). A VCE typically has 2 or more distinct operating modes. (e.g. turbofan and turbojet), each tailored to provide optimum efficiency at one of the major flight conditions, e.g. takeoff, subsonic cruise and supersonic cruise. The success of any VCE concept depends in turn on the proper functioning of its components -- which in many cases must operate safely and efficiently over an unprecedented range of operating conditions. In order to provide technology readiness for these components, studies will be conducted to: identify those for which the payoff for technology advancement is highest, determine (in the case of a variable geometry component) the optimum degree optimum degree of variability, and select the most promising design approaches. The components initially considered will include but not be limited to the following: highly variable fans; variable HPC's, HPT's, and LPT's; variable exhaust systems, burners, mixer valves and flow diverter valves.

W76-70216 **516-56-01**
Langley Research Center, Langley Station, Va.
HYPERSONIC AIRCRAFT SYSTEMS TECHNOLOGY
R. E. Bower 804-827-3285
(505-11-31; 505-04-21; 501-22-06)

The purpose of this work is to provide the technology required for flight demonstrations and tests of advanced propulsion and structural systems associated with achieving efficient sustained hypersonic flight. In addition, this work is to support jointly with USAF the configuration development, thermal protection system verification and rocket engine selection for the test vehicle (X-24C) on which the experiments would be carried. A joint USAF-NASA ad hoc committee has developed a research aircraft concept meeting the flight research requirements of both agencies. Detailed work on configuration development including integration of the major flight experiments such as a scramjet will be conducted. Further, the verification of the thermal protection system and studies leading to the final selection of the rocket primary propulsion system will be conducted. In addition, this program (in cooperation with the R&T disciplinary research programs) will develop the technology for advanced systems demonstrations for eventual flight test on the X-24C. Technology development leading to the fabrication and ground test of a flight-weight scramjet module designed to fully integrate with the vehicle as well as the development and test of liquid hydrogen fuselage tanks and advanced structural panels will be sponsored under this RTOP.

W76-70217 **517-51-01**
Flight Research Center, Edwards, Calif.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
Weneth D. Painter 805-258-3311
(517-51-02; 517-51-03)

The objectives of this effort are: (1) to demonstrate the supercritical wing improved transonic drag rise and lift levels for buffet onset shown in wind-tunnel investigations; and (2) establish the desired level of confidence in prediction of supercritical wing characteristics for future applications. This is a joint NASA/USAF program being conducted in accordance with a Memorandum of Understanding dated 16 June, 1971. The supercritical wing and associated parts were provided by Convair Division of General Dynamics under Air Force Contract AF 33615-71C-1912. The left-hand wing was structurally proof tested at the AFFDL Wright-Patterson AFB. NASA FRC will supply and install the basic instrumentation as well as perform the aircraft modification and wing installation. NASA FRC will also be responsible for the flight test and total program management beginning at the end of the envelope expansion phase of the flight test. NASA FRC assumed responsibility for the TACT program management as of August 28, 1974.

W76-70218 **517-51-02**
Ames Research Center, Moffett Field, Calif.
F-111 TACT RESEARCH AIRCRAFT
R. H. Petersen 415-965-6463

The overall objective of the Transonic Aircraft Technology (TACT) program is to provide a proof-of-concept research flight demonstration of recent advances in supercritical wing technology leading to the development of design criteria for future military and civil aircraft. Specifically, the effort at the Ames Research Center will be to provide thorough wind tunnel investigations as the basis for prediction of aerodynamic performance, stability, control, buffeting characteristics, and structural loads of the TACT airplane. Correlation of the predicted characteristics based on the wind tunnel results with full-scale flight test data is a further major objective. Current projections are that all wind tunnel test data require for the correlation of wind tunnel and flight test results will be obtained by end of FY-77.

W76-70219 **517-51-03**
Langley Research Center, Langley Station, Va.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
R. E. Bower 804-827-3285

The overall objective of the Transonic Aircraft Technology (TACT) program is to provide proof-of-concept of supercritical airfoil technology in the transonic and low supersonic flight regimes and to provide design criteria for the design of future military and civil aircraft. The effort at the Langley Research Center will be to analyze and document wind tunnel test results of the nozzle thrust-minus-drag and fuselage afterbody drag coefficients for use in correcting static aerodynamic data to full scale airplane values for various engine power settings. The Langley effort will also provide technical assistance for the correlation and analysis of the wind tunnel and flight aerodynamic data.

W76-70220 **517-51-04**
Flight Research Center, Edwards, Calif.
MILITARY SYSTEMS TECHNOLOGY
T. R. Sisk 805-258-3311

NASA-FRC has obtained permission to participate in several AF development and flight programs of highly maneuverable aircraft. Being involved in these programs permits FRC to obtain an early insight into many of the design innovations of these advanced technology aircraft and allows detailed planning of follow-on programs to compare to model data and analytical prediction methods. Some of the areas of interest include: (1) stability and control characteristics at high angle of attack and advanced load factor, (2) buffet/wing rock characteristics: (3) effects of maneuver enhancement devices such as flaps and strakes; and (4) effects of advanced design features such as RSS and canards.

Aeronautics Experimental Programs

W76-70221 **723-01-01**
Flight Research Center, Edwards, Calif.
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HiMAT) - FLIGHT RESEARCH PROGRAM
G.P. Layton 805-258-3311
(505-06-44)

This RTOP covers the flight test phase of a program to provide improved technology for the design of highly maneuverable aircraft. Present design restraints will be relaxed to permit complete freedom in the application of state-of-the-art system such as integrated, computerized controls, composite structures, propulsion augmentation of lift and control and the like in order to achieve maximum benefits from synergistic effects. The complex and innovative configurations such as the HiMAT designs can only be validated and the high risk technology matured for manned vehicle application through extensive testing of the complete configuration in the real and dynamic environment of flight. The high level of technical risk inherent in the HiMat designs precludes their application to manned prototype vehicles because of pilot safety concerns and the enormous cost of these aircraft. This program will use large scale free-flying models controlled by remote piloting techniques to acquire actual flight tests data at a minimum cost. The facility for these tests exists at FRC and is currently being extended to handle supersonic vehicles.

W76-70222 **723-01-03**
Langley Research Center, Langley Station, Va.
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY/WIND TUNNEL SUPPORT
R. E. Bower 804-827-3285

The objective of this research is to investigate and develop the technology base required for the design and development of new highly maneuvering aircraft concepts. Study of several unconventional concepts will be pursued with the objectives of defining the subsonic stability, control and performance characteristics at high angle of attack. The successful accomplishment of the goals of this research can provide significant increases in the aeronautical performance for future fighter aircraft. Promising ideas for obtaining high aerodynamic performance for manueuvering fighter aircraft will be examined analytically and experimentally with primary emphasis on investigating their aerodynamic performance, propulsion, stability, and control characteristics. Representative promising concepts which may be investigated include configurations employing high respect ratio, two-dimensional, vectoring nozzles; new and innovative wing designs including aeroelastic tailoring, and anti-spin deveices. The experimental studies will be conducted primarily in the Langley 16-foot, 7- by 10-foot, spin, and 16-foot transonic dynamics tunnel.

W76-70223 **738-01-01**
Lewis Research Center, Cleveland, Ohio.
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE)
Carl C. Ciepluch 216-433-4000
(505-05-22)

The objective of this program is to design, build and test experimental engines to consolidate and demonstrate the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable powered lift short-haul aircraft. Two experimental propulsion systems, engines and nacelles, one for under-the-wing and one for over-the-wing installation, will be designed, built, tested and delivered to the Lewis Research Center. Acoustic and aerodynamic performance testing in wing/flap system installations will be conducted to verify system characteristics and achievement of program goals.

W76-70224 **743-01-01**
Langley Research Center, Langley Station, Va.
SCAR - STRUCTURAL CONCEPTS
R. R. Heldenfels 804-827-2042
(743-01-11; 732-01-12; 732-01-22)

The objective is to assess merits of structural arrangements, concepts, and materials for advanced supersonic aircraft and determine best approaches. Perform studies to develop baseline structure for arrow-wing aerodynamic configuration and guidelines for future research. Acquire analysis and design tools for future in-house studies of advanced configurations. Develop advanced composite panels for low-weight and high fracture-resistance. Assess impact of application of composite structures in a continuation of Boeing structural concept study contract. Perform sensitivity studies in-house with LTV team to examine impact of structural modifications and composites on aeroelastic behavior. Purchase advanced composite panels for testing in-house.

W76-70225 **743-01-02**
Ames Research Center, Moffett Field, Calif.
FUEL TANK SEALANTS
D. R. Chapman 415-965-5065

The objective of this RTOP is to develop fuel tank sealants which offer long service life under conditions encountered in advanced supersonic aircraft. The specific objectives are to: synthesize, characterize and vulcanize sealant elastomers; study mechanism(s) by which they deteriorate on exposure to heat both in the presence and absence of fuels; select optimum sealant and determine its thermophysical and dynamic properties; and evaluate it by performing appropriate environmental and flight testing. Novel elastomers will be synthesized as candidate fuel tank sealants designed to meet flight requirements of Mach 2.7-3.0 and higher. The mechanism sealants will be selected, compounded and tested under simulated fuel tank conditions to establish their long term service life. The optimum sealant will then be applied to a fuel tank in an advanced aircraft and flight-tested.

W76-70226 **743-01-11**
Langley Research Center, Langley Station, Va.
SCAR - COMPUTER-AIDED DESIGN
R. R. Heldenfels 804-827-2042
(743-01-01; 743-01-12; 743-01-22)

The objective is to develop computer-aided design methods for supersonic cruise vehicles with particular attention to aeroelastic, flutter, thermal stress, and fatigue and fracture considerations. Under grants and contracts, extend or improve computer codes for design-oriented aerodynamics, fatigue and fracture design, and flutter optimization. In-house, define component processes for a flutter design computer code module.

W76-70227 **743-01-12**
Langley Research Center, Langley Station, Va.
SCAR - LOADS AND AEROELASTICITY TECHNOLOGY
R. R. Heldenfels 804-827-2042
(743-05-04; 743-01-11)

Under the specific objective to establish an expanded supersonic structures and materials technology base in parallel with the expansion of other supersonic disciplinary technologies which will permit major reductions in structural weight by research on new materials with satisfactory fatigue, fracture, and lifetime characteristics under supersonic cruise conditions, the objective of this plan is to develop, in-house and with contract support, technology in the area of loads and aeroelasticity to a sufficient state of readiness to provide an adequate base for confident initiation of development of advanced supersonic cruise aircraft. A multi-faceted approach will be used to meet this objective. The development of advanced flutter analysis theories will provide improved inputs to the flutter design module now being developed (743-01-11) particularly in the transonic and low supersonic speed regimes. Loads analysis techniques to include aeroelastic and nonlinear transonic effects will be developed. Both existing and new wind tunnel experimental results will be used to verify and improve analysis techniques. Acoustic pressure inputs from the engine exhaust will be quantified and the response of various structures will be analyzed. A program to predict aircraft landing, taxi and takeoff motion will be formulated and the benefits of an active landing gear on the ride quality and loads will be determined. Related work is being done at Langley, Ames and Flight. The DOT SST technical follow-on program has related tasks which have been considered in developing this program.

W76-70228 **743-01-13**
Langley Research Center, Langley Station, Va.
SCAR - ATMOSPHERIC TURBULENCE
R. R. Heldenfels 804-827-2042

The objective is to establish and expand supersonic structures and materials technology base which will permit major reductions in structural weight for supersonic cruise conditions and to establish the aeroelastic behavior of highly flexible long and slender aircraft in the transonic and supersonic flight regime. Detailed definition of power spectra of turbulence and wave motion characteristics present in the atmosphere in various meteorological conditions will be obtained. Special emphasis will be placed on the determination of the spectral shape at wavelengths of 30,000 ft or greater and altitude of 30,000 to 65,000 ft. Meteorological conditions will include jet stream, mountain waves, gravity waves, and near thunderstorms as well as earth boundary turbulence measurements, the latter primarily for instrumentation verification. Consistency of spectra and directional characteristics of wave phenomena will be investigated. All measurements will be made utilizing the same instrumentation system and same data processing procedure. Instrumentation includes low, inertial flow vanes, an inertial platform for measuring aircraft motion angles, platform mounted accelerometers integrated for aircraft velocities, and rate gyros for angular rates. A total of 60-90 flights should yield sufficient data to accomplish the objectives.

W76-70229 **743-01-22**
Langley Research Center, Langley Station, Va.
SCAR - MATERIALS APPLICATIONS
R. R. Heldenfels 804-827-2042
(505-01-31; 505-03-21; 505-02-41; 505-02-42)

The objective of this program is to advance composite and titanium materials and structural component technology to achieve longtime structural integrity and low weight in supersonic cruise aircraft structures. The technology development program will consist of development of advanced fabrication methods; performance of strength, fatigue, and fracture tests to establish structural integrity of materials and representative components; development of methods for acceleration of fatigue tests; performance of time-temperature-stress investigation to determine limitations of advanced materials; development of new or improved resins, adhesives, and coatings; and fabrication, ground test, and installation of components on the YF-12 and Boeing 737 aircraft for flight service evaluation. It is anticipated that these programs will provide important advances in materials and structural component technology; help establish the future role of advanced composite materials; and indicate approaches for achieving lower structural weight, improved structural integrity, and lower fabrication costs for supersonic cruise aircraft.

W76-70230 **743-01-23**
Flight Research Center, Edwards, Calif.
SCAR STRUCTURES AND MATERIALS TECHNOLOGY
Alan L. Carter 805-258-3311
(501-32-05; 501-32-06)

The objective is to determine the structural performance of candidate AST materials and fabrication techniques (corrugated and honeycomb sandwich, composites, conventional skin - stringer, etc.) subjected to load and thermal cycling. Conduct a coordinated program of flight and laboratory tests on specimens supplied by Langley. For the flight program, representative panels would be designed, fabricated and flight rated under contract and installed on the YF-12 for exposure to realistic operating environment during NASA flight tests. Subsequently the panels would be subjected to thermal and load testing in the FRC Heat Facility. In addition, a series of small specimens, supplied by Langley, will be tested in the laboratory for additional background information.

W76-70231 **743-02-22**
Langley Research Center, Langley Station, Va.
SCAR - STRATOSPHERIC EMISSION IMPACT - TUNABLE LASER MEASUREMENTS
E. S. Love 804-827-2893
(506-18-12)

The objective of this research is to develop laser flight instrumentation to measure trace constituents in stratospheric jet wakes and the effect of these constituents on the ambient stratosphere. This RTOP continues a program initiated in FY-73 [501-24-20]. A feasibility study under that program identified tunable laser instruments which are capable of making fast time response spatially resolved measurements of jet wake constituents with greater sensitivity than currently available in-situ techniques. Under an FY-74 program (743-34-22) a Phase A contractual design and cost study of a flight instrument for two-ended diode laser absorption demonstrated the feasibility of a two-ended absorption measurement operating between the cabin of a chase aircraft and a wing-mounted retroreflector. The approach to this program will be to continue a phased contractual program. An FY-75 contract will be initiated to provide in-flight wing motion measurements of the U-2 aircraft and to design and build a wing tracking mirror. An FY-76 contract will be let for design and construction of the flight instrument. In-house laboratory and theoretical studies will be continued to provide calibration spectra for the jet wake and stratospheric constituents.

W76-70232 **743-02-22**
Ames Research Center, Moffett Field, Calif.
SCAR - STRATOSPHERIC EMISSION IMPACT
D. R. Chapman 415-965-5065
(989-15-20; 505-03-41; 976-61-11)

The basic objective is to develop an understanding of the interaction of supersonic jet exhausts with the upper atmosphere to provide data which can be used to assess wake impact on the natural atmospheric composition. Detailed objectives are to determine composition of the jet wake and the perturbations (chemical, fluid-dynamic) in the stratosphere caused by the passage of supersonic aircraft in a specified air corridor, and develop and apply advanced instrumentation to measure these trace constituents in the stratosphere. The Stratospheric Jet Wake Program will continue its studies in two parts: wake assessments concluding in FY-76, and far-wake evaluations, if warranted, through FY-79. Integral with these activities is an advanced instruments development program. The near-wake studies involve the use of newly available instruments on a U-2 aircraft flown into the visibly-marked wake of a supersonic aircraft in the stratosphere to measure exhaust gases. These data are being used to improve and verify mathematical models of engine exhaust wake chemistry. Fluid-dynamic models of the wake are being verified by photographic methods which provide wake dimensions with time. Far-wake studies require new types of instruments being developed in the advanced instruments development program. These devices will provide sensitive measurements of very dilute exhaust gases and atmospheric constituents with which the exhaust may react. Improved wake visualization methods are also necessary so aircraft can be directed into and near aging exhaust plumes.

W76-70233 **743-03-11**
Lewis Research Center, Cleveland, Ohio.
SCAR NOISE REDUCTION TECHNOLOGY
U. H. Von Glahn 216-433-4000

The objective is to develop the technology required to quiet both conventional and advanced supersonic transport engines to levels acceptable to the community. Areas of particular concern include noise suppression of high velocity jets and choked inlet suppression of turbomachinery noise. Wind tunnel tests will be conducted using scale-model nozzles developed for advanced duct-burning turbofan engines to determine airspeed effects on the jet acoustics of such nozzles. Studies will be continued to determine the effect of aircraft motion on noise sources. External flow effects on various jet noise suppressor types and on the acoustic characteristics associated with engine cycles of interest will be evaluated.

W76-70234 **743-03-21**
Lewis Research Center, Cleveland, Ohio.
SCAR POLLUTION REDUCTION TECHNOLOGY
R. A. Rudey 216-433-4000
(505-03-32; 505-04-31; 743-02-22)

The objective is to minimize the amounts of pollutants being discharged by aircraft engines into the upper atmosphere, by

improving combustor and/or augmentor designs. Achieving low levels of exhaust emissions from high altitude aircraft by improving combustion design principles is needed in order to minimize any potential interaction of combustion products with the ambient atmosphere. Reductions in combustor exhaust emissions are being sought in two efforts. The first, which has been completed, was directed toward modification to combustor hardware presently being developed in the clean combustor program with emphasis placed on reducing oxides of nitrogen (NOx) at supersonic cruise conditions. The second approach, which is currently under way, is to evaluate novel and unique techniques to minimize NOx to the lowest values possible in combustion systems eventually applicable to aircraft engines. The first effort is aimed at the near term emission reductions that may be practical, whereas, the second effort is geared toward developing technology for future supersonic aircraft engines. The evaluation of potential augmentor emission reductions will be used to assess the impact that well designed augmentors, used during cruise, would have on total engine emission levels. The augmentor program is being initiated and a follow-on effort to the low cruise NOx efforts is being planned.

W76-70235 **743-03-31**
Lewis Research Center, Cleveland, Ohio.
SCAR INLET STABILITY SYSTEM
M. O. Dustin 216-433-4000

The objective is to demonstrate an improved inlet stability system for supersonic, mixed-compression inlets. The system will allow the inlet to operate at a higher pressure recovery with fewer inlet unstarts than for the present inlet system. The development of a shock stability bleed system using mechanical relief valves will be accomplished in wind tunnel tests using a full-scale YF-12 inlet. If successful, the stability system will be evaluated in flight on the YF-12 aircraft.

W76-70236 **743-03-41**
Lewis Research Center, Cleveland, Ohio.
SCAR ENGINE STUDY
E. A. Willis 216-433-4000

Advances in propulsion system technology will be required to permit the development of a quiet, clean, economical commercial supersonic transport. Contracts for the study of such airplanes have been let by Langley Research Center and other supporting work is being performed by LaRC, LeRC, ARC, DRC, and DOT. As part of this effort, LeRC has let contracts to study various types of propulsion systems that might be applied in the advanced aircraft. The studies will determine the desirable characteristics of the engines, assess the benefits of advanced technology, and identify the needs for future research. They also will be used to define the content of a possible experimental engine program.

W76-70237 **743-03-51**
Lewis Research Center, Cleveland, Ohio.
SCAR - TECHNOLOGY-UNIQUE COMPONENTS
R. A. Signorelli 216-433-4000

Advanced aircraft that must perform efficiently over a wide range of subsonic and supersonic flight speeds may employ variable bypass engine cycles which require a number of unique components. These components include a through-flow fan and sound suppression system which must provide a high level of performance over a wide range of flow conditions. The large complex sections must be fabricated with lightweight structural materials capable of operating at the high temperatures encountered at high flight speeds and in the hot section of the engine. Advanced composites provide the most promising materials for these structures. To provide the necessary high levels of performance and advanced materials for these unique components of variable bypass engines, the following major thrusts are included: (1) advanced boron/aluminum composite materials for lightweight fan blades with improved impact resistance will be evaluated; (2) structural and fabrication properties of an applicable high temperature composite material (silicon carbide in metal matrix) will be evaluated for use in the hot sections of the engine; and (3) supersonic through-flow fan stages applicable to a supersonic cruise engine will be evaluated.

W76-70238 **743-04-01**
Langley Research Center, Langley Station, Va.
SCAR - AERODYNAMIC PERFORMANCE TECHNOLOGY (SYSTEMS INTEGRATION STUDIES)
R. E. Bower 804-827-3285

The work performed under this RTOP will address the impact of advanced technologies applied to supersonic cruise aircraft by studying their effects on the overall characteristics and mission capabilities of promising aircraft concepts. Integration studies will typically evaluate advances in aerodynamics/configurations, propulsion, structures, materials, and avionics. These studies will not only indicate the most favorable design trade-offs, but will also point out the directions for productive future research and technology activities. Throughout the studies, major considerations will be the meeting or exceeding of current noise and pollution levels and improving the energy utilization of supersonic cruise aircraft. The work will be carried out in two ways. In one, SCAR will support the supersonic technology efforts of a team from the Vehicle Integration Branch of the LRC Aeronautical Systems Division. The emphasis of this team, which is made up of in-house and nonpersonal services contract manpower, will be on providing early assessments of new technology on the characteristics of the total aircraft, and on defining reference configurations for future comparison purpose. In the other approach, industry expertise will be utilized by awarding contracts in areas of particular company capability or initiative, and where practical design and construction methodology needs to be considered.

W76-70239 **743-04-12**
Langley Research Center, Langley Station, Va.
SCAR AERODYNAMIC PERFORMANCE TECHNOLOGY (CONCEPTS)
R. E. Bower 804-827-3285

The objective of this program is to develop advanced supersonic cruise vehicle concepts and to provide a source of experimental data which can be used in the optimization of these concepts. The goal is to provide fully integrated configurations which provide at least a 30 percent improvement in supersonic cruise efficiency while meeting the requirements of other disciplinary areas such as structures, propulsion, and flight controls. The effort will be conducted in two ways. In one approach, in-house developments in the concept area will be analyzed and tested extensively at subsonic, transonic and supersonic speeds. Iterations will be made on the concepts and wind tunnel models will be tested to establish trade information and to provide cause and effect relationships. In the other approach, cooperative NASA/Industry programs will be supported to develop data bases and trade information on promising airframe industry supersonic cruise vehicle concepts.

W76-70240 **743-04-21**
Langley Research Center, Langley Station, Va.
SCAR-AERODYNAMIC PERFORMANCE TECHNOLOGY (THEORY)
R. E. Bower 804-827-3285
(743-04-21; 501-06-01)

The objective of this program is to develop and validate methods for use in predicting overall aerodynamic characteristics and detailed load distributions, for design and off-design conditions, of advanced supersonic aircraft configurations. Theoretical methods will be developed through contract and in-house studies and then evaluated with in-house tests of representative models of advanced supersonic aircraft. The studies will involve improvements to existing linearized-theory area rule methods and to the inclusion of local Mach number effects to allow prediction of detailed surface loadings and flow fields of complete configurations. The off-design and critical design load problems will be approached by including leading edge separation and reattachment in finite-element lifting surface theories.

W76-70241 **743-04-21**
Ames Research Center, Moffett Field, Calif.
AERODYNAMICS AND PERFORMANCE (THEORY)
C. T. Snyder 415-965-5567
(505-06-11; 505-06-31)

The research performed under this RTOP is to develop and

evaluate aerodynamic theories for use in predicting the high-lift characteristics of advanced supersonic technology aircraft, including wing-body interference, propulsive flow effects, airframe acoustic shielding effects, and ground effects. The overall objective is to provide the theoretical technology for design of advanced supersonic technology aircraft having acceptable aerodynamic and acoustic characteristics during landing, take off, and subsonic flight operations.

W76-70242 **743-04-31**
Langley Research Center, Langley Station, Va.
SONIC BOOM
R. E. Bower 804-827-3285

This RTOP is in support of the Supersonic Cruise A/C Research Program. The objectives are to provide an understanding of sonic boom generation and propagation, and to develop methods of estimation and minimization. In recognition of the substantial accomplishments already made for supersonic speeds approaching the hypersonic range, and in the absence of a national supersonic transport development program, the present research porgram is rather limited. Contract work has been terminated, and the present university grants will be discontinued this year. An in-house program of analytic studies and wind-tunnel experimentation will be continued. The work will cover refinement of minimization techniques and their application in definition of configuration requirements for low levels of sonic boom.

W76-70243 **743-05-01**
Ames Research Center, Moffett Field, Calif.
STABILITY AND CONTROL PREDICTION OF FLEXIBLE AIRCRAFT
R. H. Petersen 415-965-5880
(505-02-21; 505-06-13; 514-51-02)

The objective is to develop and incorporate into the FLEXSTAB computer program system improvements that will increase the accuracy and efficiency of analysis of stability and control characteristics of flexible aircraft, and that will add aerodynamics design capability, and analysis of maneuver and gust loads and active control characteristics. To apply the FLEXSTAB for configuration analysis in support of SCAR Program objectives and to make the program available to aerospace industry. Contracts have been obligated with previous fiscal year SCAR Program funds that are still in progress that will provide much of the new technology needed to accomplish the above objectives. Although no new funding is requested in FY 1976, costs will be incurred during FY 1976 from the existing contracts.

W76-70244 **743-05-04**
Langley Research Center, Langley Station, Va.
ACTIVE CONTROL OF AEROELASTIC RESPONSE
R. R. Heldenfels 804-827-2042
(512-53-01)

In order that dynamically scaled aeroelastic wind tunnel models may be used to study and validate active control applications for the minimization of aircraft aeroelastic response, the state of the art of modeling technology, including model design and construction and testing techniques, will be advanced as required for active control applications. In addition to basic technique development, considerable emphasis will be placed on validating model procedures by correlating wind tunnel results with analytical and flight data. In order that future supersonic cruise aircraft can take full advantage of the potential benefits of active control for the minimization of aeroelastic response technology, research will be conducted to develop new active control concepts and approaches that are particularly applicable to SCAR class aircraft. The efforts are designed to help meet the general objective of establishing an expanded supersonic stability and controls technology base in parallel with the expansion of other supersonic disciplinary technologies which will provide major control system advances applicable to aircraft operating at supersonic cruise speeds.

W76-70245 **743-05-22**
Flight Research Center, Edwards, Calif.
SCAR-COOPERATIVE AUTOPILOT/SAS/PROPULSION CONTROL SYSTEM
Gene J. Matranga 805-258-3311

Significant airplane flight path disturbances attributable to the propulsion system, have been observed on the XB-70 and YF-12 airplanes at high speed. This RTOP is developing wind-tunnel and analytical techniques for predicting airframe/propulsion system interactions of advanced supersonic aircraft and determining the feasibility and benefits of a cooperative autopilot/SAS/propulsion control system. This goal is being pursued by conducting simulator and analytical studies to determine the possible benefits to be derived through the use of such an integrated control system on the YF-12. Contracts are being let for the design, construction, and installation of such a system on the YF-12. Flight tests are planned to verify the benefits that can be obtained by such a system in an operational environment.

W76-70246 **743-05-31**
Langley Research Center, Langley Station, Va.
ACTIVE FLUTTER SUPPRESSION OF SUPERSONIC CRUISE AIRCRAFT
R. R. Heldenfels 804-827-2042

Active flutter suppression systems appear to be attractive for application to future flutter deficient aircraft designs from performance and costs points of view, since the potential exists for considerable weight savings as compared to traditional passive approaches of increasing structural stiffness and/or mass balancing. However, specific comparisons of active and passive solutions to increasing flutter speeds are needed so that the quantitative benefits of active systems can be determined. This is the objective of this RTOP. The objective will be reached by using contractor studies to compare active and passive flutter suppression applications to increasing the flutter speeds of particular structural configurations.

W76-70247 **744-01-01**
Ames Research Center, Moffett Field, Calif.
TILT ROTOR RESEARCH AIRCRAFT PROGRAM
W. L. Cook 415-965-5442
(744-01-01)

The design, development and flight research on two tilt rotor research aircraft are proposed to prove the tilt rotor V/STOL concept for potential military and civil missions. A program of direct supporting technology is also a part of this RTOP. The Project Plan for Development of V/STOL Tilt Rotor Research Aircraft, Revision 2, dated January 1974 and Change 1 to the same, Dated September 1974, address the technical objectives, approach, justification, the operating plan, environmental impact statement, milestone schedules and the review and reporting for the subject project.

W76-70248 **745-01-01**
Langley Research Center, Langley Station, Va.
ROTOR SYSTEMS RESEARCH AIRCRAFT (RSRA)
Robert E. Bower 804-827-3285
(505-10-24; 505-10-21; 505-10-23; 505-10-26; 514-53-01)

The Rotor Systems Research Aircraft (RSRA) objective is to develop and bring into operation two versatile flight research aircraft to provide economical rotorcraft research capability in the real and dynamic environment of flight. These research aircraft will provide research capabilities that cannot be duplicated in groundbased facilities and that have previously been restricted because of the expense of specialized vehicles. The versatility of the Rotor Systems Research Aircraft will provide: (1) economical flight research of a wide variety of promising new rotor concepts, and (2) real-world verification of rotorcraft supporting technology offering potential solutions to existing or anticipated problem areas. This is a joint program with the Army, in accordance with the Memorandum of Understanding between NASA and the Army dated November 1, 1971. The program will be managed through a joint project office in accordance with the NASA/Army Rotor Systems Research Aircraft Project Plan which was jointly approved by NASA and the Army on February 23, 1973, and updated February 7, 1974 by the NASA/Army RSRA Project Office.

W76-70249 **769-01-01**
Ames Research Center, Moffett Field, Calif.

AMST PROGRAM PARTICIPATION
C. Thomas Snyder 415-965-5567
(769-38-01)

This RTOP provides for participation by NASA/Ames in the Air Force AMST program and for the subsequent use by NASA of the AMST aircraft. NASA's role in the AMST program includes joint planning with the Air Force of the flight test program, arrangements for the provision of special instrumentation or modifications to the aircraft, arrangements for the performance of support effort in wind-tunnel and simulator facilities, the conduct of additional analyses and tests in support of NASA's unique flight test requirements for the AMST, and participation with the Air Force in the Air Force flight test program, and later, the conduct of unique NASA tests of the AMST aircraft. Accomplishment of the above requires achievement of a framework for joint NASA/AF working level flight test planning. Also required is an evaluation in depth of the capabilities of the AMST aircraft to perform propulsive-lift flight research and an investigation of modifications which may enhance their flight research usefulness. The first stage of the flight test program will be devoted to achieving the Air Force primary objectives and as much as NASA's technology-oriented research as can be accomplished concurrently without interference with the primary objective. Following completion of the one year of prototype evaluation planned by the Air Force, the aircraft may be turned over to NASA for tests more closely related to NASA's flight research objectives.

W76-70250 **769-01-02**
Langley Research Center, Langley Station, Va.
AMST EXPERIMENTS PROGRAM PARTICIPATION
R. E. Bower 804-827-3285
(505-10-41)

The objectives are to obtain, through participation in the U. S. Air Force advanced medium STOL transport (AMST) prototype aircraft program, upper-surface blowing and externally blown flap propulsive-lift flight research data. The Langley Research Center will supply principal investigators to plan and help execute specific experiments in various discipline areas. A Langley representative will serve on the Inter-Center Quiet Propulsive-Lift Technology (QPLT) Flight Experiments Working Group where the NASA experiments will be planned, evaluated, and integrated into the joint flight test program with the Air Force-led flight tests and later NASA-led flight research utilizing both the Boeing YC-14 and Douglas YC-15 AMST aircraft. For justification, see specific objective and targets for AMST experiments, quiet propulsive-lift technology, page 31-1, PASO Document dated February 1, 1975.

W76-70251 **769-01-03**
Flight Research Center, Edwards, Calif.
AMST FLIGHT EXPERIMENTS
M. R. Barber 805-258-3311

This RTOP covers FRC activities pertaining to support of the joint Air Force/NASA AMST program and activities. Specific areas involved are: (1) participation on the AMST Joint Test Team; including flight test planning, developing NASA proposed flight experiments, developing research instrumentation and data acquisition requirements, in-house data reduction and analysis, and information dissemination; (2) proposing, reviewing, developing, initiating, and assisting other NASA Centers in implementing flight experiments derived from the QPLT Flight Experiments Working Group; (3) measuring the noise characteristics of the AMST aircraft; and (4) investigating control system/stability and control requirements and operating environment for follow-on NASA Lead AMST flight experiments. All of the above listed *activities were essentially new efforts in FY-74 covered under* the RTOP 769-89-01.

W76-70252 **769-01-04**
Lewis Research Center, Cleveland, Ohio.
AMST EXPERIMENTS PROGRAM PARTICIPATION
Michael F. Valerino 216-433-4000

This RTOP provides for Lewis Research Center participation in the joint Air Force/NASA AMST program which includes definition of flight research experiments in the areas of propulsion system performance and noise to be conducted using the Boeing YC-14 and Douglas YC-15 prototype aircraft. LeRC will define, develop, and implement NASA propulsion-related flight experiments to be conducted during the Air Force-led portion of the AMST flight test program and during the subsequent NASA-led flight research program.

W76-70253 **769-02-01**
Lewis Research Center, Cleveland, Ohio.
QSRA PROPULSION SUPPORT
M. F. Valerino 216-433-4000

LeRC is supporting ARC in the propulsion systems of the QSRA aircraft, including the study of engines potentially suitable for the research aircraft in achieving its powered lift, noise, and near terminal performance goals. Based upon the results of these and the aircraft studies, the hybrid upper surface blowing system has been selected for incorporation into the Buffalo aircraft. These selections then resulted in the selection of the Lycoming YF102 series turbofan engine as that most suited for the intended application. The continuing engine support will then include further determination of modifications required to the engine to accomodate the needs of the research aircraft, and the provision of government-owned YF102 engines for the flight aircraft and for supporting ground studies by LeRC. The effort also includes participating in all other propulsion aspects of the aircraft program. In addition, assistance will be provided to the QPLT Office in its staff support role to the OAST Transport Technology Programs Office in carrying out the vertical cut responsibilities for the Short-Haul Transport Technology Program. This includes participation in the development of a Short-Haul Transport Technology Program plan.

W76-70254 **769-02-02**
Ames Research Center, Moffett Field, Calif.
QUIET SHORT-HAUL RESEARCH AIRCRAFT (QSRA)
W. L. Cook 415-965-6181
(769-02-01)

This RTOP covers the design, fabrication and test of a quiet propulsive-lift research aircraft which will permit flight research beyond the flight regime of the AMST and the existing augmented jet flap Buffalo aircraft. The approach stresses low-cost modification of another existing Buffalo aircraft. Key design simplification guidelines are use of fixed landing gear, 160 knot maximum *speed, +2g, -0.5g limit load, and design life of 500 flight hours.* The flight research will advance technology for future development of reliable, quiet, and economical propulsive lift transports. The test program will provide specific information on flight characteristics, and powered lift performance, as well as information on design, noise, operational features and propulsive-lift system economics, all needed variously by designers, regulatory agencies and operators. The research aircraft design goals include: capability of usable approach lift coefficients greater than 4.6; 90 EPNdB noise footprints smaller than one square mile, and roll control power greater than 1 rad/sec/sec. The project will include modification of an existing C-8 Buffalo aircraft into an advanced hybrid/upper surface blowing propulsive-lift configuration with updating existing Lycoming YF-102 engines with A-9A gearbox and accessories to power the aircraft in its flight research program. Refer to the following documents for all the required additional RTOP information: (1) Project Plan for QSRA October 11, 1974; (2) Flight Test Plan for QSRA, August 1974, Risk Assessment for QSRA, September 1974; (3) Environmental Impact Statement for QSRA, September 1974.

Space and Nuclear Research and Technology Base

W76-70255 **506-16-11**
Ames Research Center, Moffett Field, Calif.
SURFACE PHYSICS
D. R. Chapman 415-965-5065

Studies are being conducted to expand the understanding of surface and interfacial properties and surface-environment interactions to determine their effects on material behavior. These

studies range from describing the changes in surface properties that result when atomic and molecular beams interact with solid surfaces to the study of the growth characteristics of thin films and of the nature of composite interfaces. In addition, a study was initiated to correlate grain boundary chemistry of fracture surfaces and embrittlement of structural materials. This study uses an Auger analysis system and has the capability of fracturing and examining in-situ a variety of metal alloys in aggressive environments. Other experimental studies will involve in-situ high resolution electron microscopy of thin film nucleation and growth phenomena in ultra-high vacuum under well controlled experimental conditions. Additional high resolution electron microscopy work has been initiated to investigate gas/solid interactions of small metallic particles (10-100 A) of interest to catalytic reactions. Thin particulate Pd films of well defined properties will be prepared to study the influence of particle size and structure on their surface free energy and catalytic activity. LEED/Auger/work function/thermal desorption studies of the interaction of metal vapors and gaseous species with metal and graphite surfaces will continue and concentrate on the effect of thin intermediate oxide layers on the atomistic properties of metal/metal interfaces. The Auger-microprobe capability will be further developed.

W76-70256 **506-16-12**
Lewis Research Center, Cleveland, Ohio.
PHYSICS AND CHEMISTRY OF SOLIDS
R. A. Lad 216-433-4000
(506-16-14)

The objective is to increase the base of understanding of the relationships between the electronic, atomic, molecular and microscopic structures of solids and their useful mechanical structural and chemical properties: the focus is mainly on basic problems associated with metal matrix composites, the hot corrosion of superalloys and the functioning of battery separators. The emphasis in composites is on phenomena which contribute to low impact strength, a wide spread in mechanical properties and deterioration during thermal cycling. The emphasis in hot corrosion is on the study of the kinetics and mechanism of the reaction, the composition of the gas phase and solid phase chemical species involved, and the thermochemistry and thermodynamics of the reactions. The battery separator research is focussed on definition of the requisite film properties for good ionic conduction and on the determination of factors which control density formation and film penetration.

W76-70257 **506-16-12**
Ames Research Center, Moffett Field, Calif.
PHYSICS AND CHEMISTRY OF SOLIDS
D. R. Chapman 415-965-5065

The objective is to develop efficient computer programs to calculate reliable wave functions for ground and excited states of atoms, diatomic molecules, polyatomic molecules, and solid state matter. These wave functions will in turn be the basis for precision calculation of many basic properties of matter such as bond dissociation energies, radiation transition probabilities, dipole moments, Auger transitions, chemical rate coefficients, and solid state properties. Computer codes for calculating wave functions using the CDC 7600 and the parallel processing feature of the ILLIAC 4 will be developed. These codes will be compared with the best available numerically computed wave functions, to assure the coding is reliable, then they will be used to calculate larger expansions of these wave functions, which will be more precise than heretofore, and also wave functions for species which have not yet been computed. Several low-lying states of each symmetry type will be computed, and optical transition probabilities between these states will be evaluated. The work will concentrate on molecules such as CN, ClO, NO(+), N2(+), ClOO, etc. which are of current interest with regard to upper atmosphere pollution, planetary entry, heat shield ablation, or gas lasers.

W76-70258 **506-16-13**
Langley Research Center, Langley Station, Va.
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATION
E. S. Love 804-827-2893

Four related research efforts comprise this program. (1) Research on GaAs epitaxial solar cells is directed toward achieving high efficiency, high temperature, radiation stable solar power for space and terrestrial application. Improved substrate material and ultra-thin GaAlAs epi-layers will be employed to improve efficiency. Improvements are being made in junction formation, surface properties, and electrical contact technologies with in-house and contractual research. (2) Research and development of delayed chemiluminescence pollution detectors will develop rubrene as an ozone detector and assess other materials for the detection of other atmospheric pollutants (e.g., diaminobenzoic acid for NO2). An indepth effort is being made to develop the technology for use as a personal pollution exposure monitor. EPA co-sponsorship of this work will continue. Practical measurements of reaction parameters as a function of temperature, time, O3 concentration, etc., and fundamental measurements of reaction products and the chemical mechanism are being made. (3) Sophisticated quantum mechanical techniques are being used to investigate sunlight excited O2 reacting with NO to explain anomalous observations in photochemical smog and photoexcited SO2 reacting with molecular H2O. These calculations will yield energies of reaction and reaction products which are critical to proper detection and alleviation of NO and SO2. (4) The floating Gaussian orbital computations of solids and surfaces are providing a method for computing energy and structure to obtain general chemical trends and to predict chemical behavior.

W76-70259 **506-16-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS
T. Vrebalovich 213-354-4530
(506-18-33)

This program pursues basic investigations into new technologies needed to meet NASA's unique requirements for electronic components. Investigations are directed at thin MOS structures, Schottky barrier solar cells, and superconducting Josephson junctions. Thin MOS (metal-oxide-silicon) structures with oxide thicknesses on the order of 100 A are being investigated by three tasks for their application in ultra-high-density microelectronics which will make on-board data processing practical. This technology is predicted to come through normal commercial development in 10 to 15 years, but a well-directed effort in this program can help lay the groundwork to foreshorten this time by a least five years. Two tasks attack basic questions on the properties and limitations of these thin MOS structures with unique techniques recently developed at JPL, involving resonant tunneling and X-ray photoelectron spectroscopy. A third task on Submicro Microelectronics is an expansion of existing activities to investigate the limitations of submicron-sized MOS devices with 100 A thick gate oxides. Schottky barrier solar cells are being investigated for development into low-cost, high-efficiency cells which could have major impact in the space program. The effort is directed at optimizing the metal-semiconductor contact on III-V compounds. This approach eliminates the recombination problems of GaAs junction solar cells. Superconducting quantum detectors are being investigated by two tasks for applications in the millimeter and far-infrared wavelengths. The approach includes the study and improvement of weak-link devices used directly as detectors, and also the study of such devices with an infrared-actice overlay to improve sensitivity and selectivity. Studies are also being undertaken to increase operating temperatures for improved performance and reduced refrigerator requirements.

W76-70260 **506-16-14**
Lewis Research Center, Cleveland, Ohio.
INTERDISCIPLINARY LABORATORIES FOR MATERIALS RESEARCH
R. A. Lad 216-433-4000
(506-16-12)

The objectives are to obtain new understanding of the relationships between electronic, atomic, molecular and microscopic structures of solids and their useful mechanical, structural, electronic and chemical properties; to employ the expertise existent in universities to obtain knowledge in those areas of

direct interest to NASA long range programs. Interdisciplinary and multidisciplinary research involving several departments is conducted at 3 universities in areas recommended by consultations with a committee composed of representatives from Headquarters, LeRC, LaRC and ARC. Research areas under study are: Rensselaer Polytechnic Institute - (1) mechanical and structural properties of metals, composites and polymers; (2) surfaces and interfaces of crystalline solids; and (3) relaxation and transport properties in solids. Rice University - (1) stress corrosion and hydrogen in metals; (2) optical and magnetic memories; and (3) polymers and high temperature materials. University of Washington - (1) solid electrolytes; (2) ceramic fibers; and (3) ceramics processing.

W76-70261 **506-16-15**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NON-METALLIC SUPERCONDUCTORS
T. Vrebalovich 213-354-4530

The primary objective is to determine the possibility of synthesizing a high temperature superconductor. The feasibility of obtaining a high temperature superconducting state depends upon the effective utilization of the excitonic mechanism. This mechanism may be optimized, or enhanced considerably, thru the use of quasi one dimensional (1D) structures. A strong excitonic interaction can yield a high temperature excitonic superconductor directly. A moderate interaction may result in a highly conducting 1D metal in which a high temperature infinite conducting state is possible via the Frohlich collective mode (Frohlich superconductivity). Therefore, the approach will involve a coordinated experimental and theoretical effort directed towards the investigation of quasi-1D organic and organometallic structures in which the excitonic interaction is stressed. The experimental program will consist of chemical synthesis and physical characterization efforts. The chemical synthesis effort will emphasize structures containing (1) cation radicals and anion radicals, (2) polymers containing highly polarizable heteroatoms and radicals, and (3) organometallic coordination compounds with highly polarizable (excitonic) ligands. Physical characterization will involve electrical, magnetic, optical, and X-rays measurements. Prof. A. Hermann of Tulane University, under a subcontract, will carry out thermoelectric power and photoconductivity measurements of single crystals and thin film samples to assist the JPL experimental effort. Prof. W. Little of Stanford University, also under a subcontract, will carry out normal reflectivity measurements on single crystals.

W76-70262 **506-16-16**
Lewis Research Center, Cleveland, Ohio.
RELATIONSHIP OF ATOMIC STRUCTURES WITH MATERIAL PROPERTIES
W. D. Klopp 216-433-4000
(506-16-21)

The objectives of this program are to elucidate the relationships between atomic and microstructural properties for refractory metal, iron-, and nickel-base alloys and to relate these to useful engineering materials properties in order to help guide the development of these materials for advanced space applications. This research program is conducted primarily through grants with universities plus a limited in-house effort. The current projects include: (1) determination of the relationship and mechanism of grain-size effects in creep of nickel and binary nickel alloys, (2) determination of the threshold stress for diffusional creep of dispersion-strengthened alloys, (3) correlation of electronic properties of dilute body-centered-cubic alloys (including Mo, Nb, and Fe alloys) with the low temperature solution softening observed in these alloys, and (4) investigation of the microstructural contributions to the inverse relationship between fracture toughness and strength for 300-grade maraging steel.

W76-70263 **506-16-17**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
VISCOELASTIC PROPERTIES OF POLYMERS
T. Vrebalovich 213-354-4530

This is a program of fundamental research on the mechanical behavior of polymers. It is intended to determine the molecular parameters which control rheological behavior. This has been successful in simple amorphous rubbery systems which are not chemically reacting. The goal now is to extend this work first to longer times, where degradation may set in, and then to shorter times, where the material is glass-hard. At the same time a modified theory must be developed to describe crystalline and polyphase systems. The general approach involves the syntheses of both new and modified polymeric and prototype chemical structures, the characterization of these materials and the determination of chemical structure, morphology and property relationships. Applications for the mechanical properties work might range from improved solid propellants, expulsion bladder and valve seat materials for liquid propulsion systems, sealants for high-speed aircraft, new types of reinforced plastics, and high reliability belts and tapes for spacecraft magnetic recorders.

W76-70264 **506-16-21**
Langley Research Center, Langley Station, Va.
ADVANCED MATERIALS FOR SPACE
R. R. Heldenfels 804-827-2042

The objectives of this research are: (1) to identify mechanisms of mechanical property degradation in advanced materials such as metal matrix composites; (2) to expand capability to predict mechanical property degradation of these materials; (3) to define the operating conditions for which these materials are suitable; and (4) to modify the materials to improve properties and reduce degradation. Metal matrix composites such as Borsic/Ti, B/Al, and Borsic/Al will be subjected to thermal and mechanical cycles. Residual mechanical properties will be evaluated, and degradation of these properties will be correlated with microstructural changes. Analyses of diffusion, phase change, and chemical reactions will be developed, and these analyses will be applied to predict microstructural changes. These analyses will then be extended to predict residual mechanical properties directly in terms of thermal and loading histories. Finally, with this quantitative analysis in terms of materials variables available, the materials will be modified to reduce degradation.

W76-70265 **506-16-21**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MATERIALS AND MANUFACTURING PROCESSES
N. T. Saunders 216-433-4000
(506-16-16)

The objectives of this program are to characterize the suitability of present materials and to develop improved materials and manufacturing processes for advanced space systems, such as power-generation systems, communications systems, propulsion systems, and reentry vehicles. This is a combined in-house and contractual effort with current projects directed at the following: (1) development of new iron-base alloys with high fracture toughness over a wide range of temperatures (-196 C to 540 C) (2) improvement of the long-time, high-power transmission properties of laser window materials; (3) determination of space environmental effects on properties of columium-base and nickel-base alloys; and (4) improvement of the manufacturing process control of boron/aluminum composites to achieve more consistent and greater design-allowable mechanical properties.

W76-70266 **506-16-22**
Lewis Research Center, Cleveland, Ohio.
MATERIALS FOR LUBRICATION AND WEAR IN MECHANICAL COMPONENTS
R. L. Johnson 216-433-4000
(505-04-41)

The objectives are to obtain greater understanding of the structure of materials to eliminate empirical approaches in the selection of materials for lubricants, seals, bearings and other mechanical components; to extend the technology of application methods improved materials including designs for optimized solid and fluid mechanics in mechanical components for the real and anticipated extreme environments of aerospace devices; also, the utilization of aerospace materials and tribological concepts for the general benefit of mankind; and further, to pursue solutions to anticipated lubrication, hydraulics and mechanical components problems for aerospace vehicles such as the space shuttle engine and vehicle as well as for advanced aircraft.

W76-70267 **506-16-31**
Goddard Space Flight Center, Greenbelt, Md.
SPACE VEHICLE THERMAL CONTROL, HEAT PIPES
R. McIntosh 301-982-6071

The objectives of this task are to improve both the capability and reliability of spacecraft temperature control in the following manner: develop more reliable heat pipes and vapor chambers in the ambient and cryogenic temperature range, and by development of stable thermal control coatings. The approach considered for the heat pipe development is: (1) develop reliable high performance heat pipes for ambient temperature; use this technology to develop isothermal vapor chambers, and extend the temperature range to the cryogenic region; (2) investigate the problems associated in integrating a cryogenic heat pipe and IR type detectors; (3) establish acceptable standards for the manufacture and testing of heat pipes; and (4) for the coatings development the approach is to develop low alpha/E coatings which have low outgassing and well defined reproducible optical properties.

W76-70268 **506-16-31**
Ames Research Center, Moffett Field, Calif.
CONTROL OF ENVIRONMENTAL EFFECTS
John V. Foster 415-965-5083

The objectives are: (1) to develop basic control mechanisms by which heat pipes may achieve variable conductance, feedback control, or thermal diode performance; (2) to improve liquid transport capacity and reliability; and (3) to participate in flight tests of advanced heat pipe technology to establish flight level confidence. The Ames Research Center shall act as the lead OAST Center and provide guidance to IA, OSS, and OMSE in this capacity as a means of extrapolating basic understanding into practical missions. Development of basic control techniques will be continued with increased emphasis on cryogenic thermal diodes, vapor controlled variable conductance heat pipes, and cryogenic gas-controlled heat pipes. Liquid transport capacity and reliability will be increased through the development of higher performance non-arterial heat pipes, development of gas invulnerable and flexible arteries, and continued research into electrohydrodynamic pumping. Performance predictions and design techniques will be improved in the cryogenic region where liquid transport capacity is currently limited. The Ames Heat Pipe Experiment (AHPE) on OAO-C and the Advanced Thermal Control Flight Experiment (ATFE) on ATS-F will be supported. A new experiment to flight test a cryogenic diode, phase change material, and cryogenic fixed conductance heat pipe will be developed for Landsat-C.

W76-70269 **506-16-31**
Lewis Research Center, Cleveland, Ohio.
THERMAL CONTROL WITH HEAT PIPES
James F. Morris 216-433-4000

The objective is to establish materials, design, and processing for efficient, durable heat pipes for space applications in the cryogenic, ambient, superalloy, and refractory-metal temperature ranges. The approach is to screen compatibilities, evaluate performances, and determine lifetimes for selected heat-pipe fluid, wick, and envelope materials, designs, and operating conditions, and to use these results to propose and specify heat pipes for space applications in the various temperature ranges. Justification for this heat-pipe work appears on page 4-3.1 in the PASO document and in the following paragraph. Conventional heat pipes are self-contained, self-pumped energy-transport systems with high throughputs, small temperature drops, and numerous applications. Producing heat pipes to operate reliably and efficiently with long lifetimes requires proper material selection, design, fabrication, processing, and filling and closure techniques. A thorough knowledge of corrosion mechanisms, impurity effects, gas generation, and deposit accumulations is also necessary to prevent heat-pipe degradation and failure. This program comprises approaches to this technology for assuring the desired---

W76-70270 **506-16-33**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL COATINGS AND PHASE CHANGE MATERIALS
Donald R. Wilkes 205-453-0186
(506-16-35)

As a continuation of work in the thermal control field, our efforts will be directed toward methods of improving NASA's capabilities of controlling spacecraft temperatures. This work is divided into two tasks. The first is to complete development of the best white paint, Zn2 TiO4 pigment in an OI-650 glass resin binder, and to test this and other thermal control coatings for their environmental stability and contamination sensitivity. This best white paint will be reduced to a NASA specification coating. The second task is to further develop the Phase Change Materials (PCM) technology. With requirements for lower temperature operation and higher cyclic heat loads, PCM techniques and materials will be studied to provide PCM operation at low temperatures (below -20 C) and at higher heat capacities. The tasks covered by this RTOP have been defined to be essential technology for NASA's planned missions by the Space Transportation Systems Technology (STST) Thermal Control Working Group.

W76-70271 **506-16-36**
Langley Research Center, Langley Station, Va.
SPACE DEBRIS STUDIES
E. S. Love 804-827-2893

The objective of this RTOP is to provide spacecraft designers with current knowledge of the meteoroid environment, man-made earth orbital debris, and the effects of these on space operations. Such knowledge is basic in insuring proper mission planning and implementation. A model of the meteoroid environment in the solar system is being generated. This model will account for the interplanetary meteoroid environment and the gravity well effect of planets. All available data are being used in this effort. This is a long range effort ending in 1977. The hazard which man-made earth orbital debris presents to spacecraft is being studied under this RTOP. This hazard must be evaluated for its impact in the space shuttle era. This evaluation will form the basis of a report to be presented and distributed internationally. Laboratory experiments are part of this RTOP. The effects of meteoroid and man-made debris impacting on spacecraft and schemes to protect spacecraft against these hazards are being studied and evaluated empirically in the Langley Impact and Projectile range. The scope of the original RTOP has been expanded slightly by inclusion of work on developing space debris experiments for the Long Duration Exposure Module (LDEF).

W76-70272 **506-16-41**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENTRY TECHNOLOGY
Dean R. Chapman 425-965-5065
(506-16-43)

The objective is to develop the aerothermodynamic and abalative heat protection technology required to design spacecraft for entry into Venus and the outer planets, and to evaluate heat shield design concepts for future space exploration vehicles capable of entering atmospheres at speeds to 60 km/sec. The approach is to define the heating environments to be encountered; to minimize the heating rates and total heat loads by proper choice of trajectory, vehicle shape, and heat shield material; to evaluate available materials in simulated environments including a number of different atmospheric compositions and combined convective and radiative and convective heating loads; to develop new materials tailored to provide maximum heat protection in given environments. Heat shield materials capable of the severe entry conditions of the outer planets will be tested in arc jets and their performance evaluated. A comprehensive realistic description of the gas cap radiation environment coupled to the material response for graphitic, reflecting and transpiration cooled heat shields will be performed by carrying out computations on the Illiac computer. Proof of concept for reflecting heat shields has been demonstrated and development of more efficient reflecting heat shields will continue.

W76-70273 **506-16-42**
Ames Research Center, Moffett Field, Calif.
ADVANCED THERMAL PROTECTION MATERIALS AND EARTH ORBITAL APPLICATIONS

Dean R. Chapman 415-965-5065
(506-16-43)

The objective is to develop the thermal protection technology required for design of advanced space shuttle vehicles and earth-orbital spacecraft for the later 1980's. This program will address (1) the improvement of current reusable surface insulation (RSI) materials and development of new reusable heat shield materials, and (2) the evaluation of advanced thermal protection concepts and materials that have promise for improved performance, weight and cost savings. The effects of cyclic arc plasma exposure on new TPS materials will be studied to determine changes in crystallinity, morphology, chemical and physical properties that are related to TPS performance. The specific focus of the program shall be in three areas: (1) improvement of current reusable heat shield materials for advanced shuttle and other earth orbital vehicles, (2) advanced TPS for future earth orbital vehicles, and (3) minimum cost advanced TPS materials for shuttle in orbit heat shield repair. Analytical and experimental studies will be conducted in-house on the specific areas of interest. A number of improvements for current silica RSI such as impregnation with silicon carbide, increased firing temperature and density, development of a material using no binder and development of new coating systems are under way. This research is expected to yield a material stable to 2800 F. Among the systems to be evaluated in FY-76 are semirigidized alumina and mullite, composite silica/mullite composites and new coating systems that may be stable to over 3000 F. Low density PBI will be studied as a candidate for thermal protection of advanced earth orbital vehicles.

W76-70274 **506-16-43**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
Dean R. Chapman 415-965-5065
(506-16-42)

The performance, including reusability, of candidate heat shield materials and design configurations will be evaluated and failure modes and material modifications identified that would increase the performance potential. Immediate objectives for FY-76 include completion of materials evaluation leading to materials selection, confirmation and continued Reusable Surface Insulation (RSI) and Reinforced Carbon/Carbon (RCC) exposure to arc plasma flows leading to 'material characterization'. This is the determination of the residual thermophysical and mechanical properties after 100 simulated flights and is required for final TPS design confirmation. These material evaluation tests will be done in the Ames Aero and 20MW Pilot TPS Test Facilities. Details of the shuttle TPS designs result in elements that require evaluation in the appropriate environments. These evaluations are referred to as desing development tests--an example being tile-to-tile gap joint design. Tests to support this activity will be performed in the Ames Aero, 20MW Pilot TPS Test Facility and 60MW Interaction Heating Shuttle Panel Test Facility.

W76-70275 **506-16-43**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
R. R. Heldenfels 804-827-2042

The objectives of this RTOP are to provide heat shield testing to support the space shuttle program, and to develop improved thermal protection materials and systems for advanced vehicles such as a flyback booster. Available arc-tunnel and other facilities will be used as required to validate the space shuttle TPS. If problems are discovered in the course of this testing, in-house programs will be undertaken to find solutions. Environmental exposure testing of RSI will continue. Emittance measurements on shuttle TPS materials will continue. Technology studies of alternate shuttle TPS will be completed if facility time is available. For advanced vehicles, new materials and materials configurations will be developed with emphasis on metallic materials. High temperature creep will be studied; data will be generated on various alloys and a design methodology will be developed based on statistical analysis of the data. A model for cyclic creep will be developed. Thermomechanical processing techniques which improve creep resistance and other properties of materials will be developed.

W76-70276 **506-17-11**
Langley Research Center, Langley Station, Va.
LARGE ERECTABLE SPACE STRUCTURES
R. R. Heldenfels 804-827-2042

The objective is to provide technology which will lower cost and improve the operational effectiveness of future space systems through the creation of new concepts for expandable structures needed for antennas, solar arrays, and reflectors. The approach is to continue efforts to define LARGER, a large geometry erectable space structures experiment for shuttle. Through combined in-house and contractual studies define structural concepts for future space payloads that require large area and/or accurate geometrical shape and orientation, such as antenna or solar arrays. Preliminary industry system studies will be initiated to determine critical design conditions imposed on such structures during operation in space. Dynamic response and thermal problems unique to large area structures will be identified and investigated. Contractual studies supported by in-house analytical and experimental efforts will lead to the development of new viable concepts for typical components. Particular emphasis will be placed on new concepts for long boom type structures that have potential application to first generation shuttle missions.

W76-70277 **506-17-12**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE TANK TECHNOLOGY
R. H. Kemp 216-433-4000

Composite pressure vessels and propellant containment tanks offer a variety of attractive advantages in space vehicle applications. Due to the high structural efficiency of the constituent materials, a composite vessel is significantly lighter than an all-metal vessel. Even relatively small weight savings can be significant for upper stage vehicles such as the shuttle orbiter ($30K/lb) and tug($160K/lb). The catastrophic shrapnel-type failure of a metal vessel can be prevented by using composite vessel technology. This can provide a reliability advantage which is not directly relatable to a cost savings but is considered a major factor in selection of candidate system configurations. In addition, composite vessels have an inherent design flexibility in providing optimum combinations of thermal, structural, and weight characteristics. The principal objective of this program is to develop structurally efficient, reliable, low cost composite vessels from a variety of composite materials including S-glass, Kevlar 49, and graphite fibers in epoxy resin matrices. In this context, a pressure vessel is considered to be a complete structural system. Due to the porous nature of high-performance composite vessels, liners are required. Both structural (load-bearing) and nonstructural (thin-metal or polymeric) liners are therefore a part of this program.

W76-70278 **506-17-14**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE MATERIALS APPLICATION TO STRUCTURES
R. H. Kemp 216-433-4000

Composite materials offer a high potential for reducing the weight of many structural components. However, before full advantage can be taken of the unusual properties of composite materials in such applications, considerable material property and design information is needed. It is proposed that studies be continued that will: (1) develop analytical design techniques for predicting structural characteristics of given composite configurations and for optimizing composite structures for minimum weight, cost, or maximum efficiency; (2) provide (in-house) testing facilities for measuring the mechanical properties of fiber composites under complex loadings, environments, high velocity impact, and for determining flaw growth characteristics; (3) determine the effects of cyclic loading on the load-carrying ability of composite components with and without flaws and develop (in-house and by contract) improved finite element capability consist with NASTRAN requirements to permit improved stress analyses of fiber composite components; and (4) develop improved composite analysis capabilities for high velocity impact, flaw growth and arrest, and develop (in-house and by contract) composite systems with improved impact resistance and the methodology for assuring structural integrity. The studies outlined above have been reviewed

and coordinated with cognizant Langley Research Center personnel and do not duplicate work at that Center.

W76-70279 **506-17-15**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED CONCEPTS FOR SPACECRAFT ANTENNA STRUCTURES
R. R. McDonald 213-354-6186
(506-20-22; 645-25-02)

Outer planet and planetary missions in the 1978-1988 period will require substantially increased communication low cost capabilities. JPL studies of NASA Payload Models indicate that optimum telecommunication design for deep space missions is realized with 5 to 30 meter (15-100 ft) antennas which have much higher gain than currently used on Mariner type spacecraft, and will be dependent on the technology of furlable or erectable structures. The principal objective of this effort is to fulfill the need to develop and make available the technology required by near term flight projects (1978-1988) for utilization of new, low cost, high performance, erectable antennas. A number of furlable antenna configurations have been considered from 5 to 30 meters (15 to 100 ft) in diameter for operating frequencies up to X-band. The technical approach is to demonstrate feasibility on small scale models as close to flight hardware as possible. The design, fabrication, and preliminary mechanical and RF testing have been accomplished for a 5-meter flight-like furlable conical antenna. Final functional testing, RF evaluation and technology extrapolation to larger size antennas will be accomplished for the conical line source feed antenna during FY-76. The development criteria includes, low cost and weight per unit area of reflector, surface accuracy in the operating environment and reliability of deployment. This effort will be coordinated with Microwave Techniques and Components, RTOP Code 506-20-22.

W76-70280 **506-17-21**
Langley Research Center, Langley Station, Va.
NASTRAN (FORMERLY) GENERAL PURPOSE ANALYSIS AND DESIGN METHODS
R. R. Heldenfels 804-827-2042

The objective is to provide advanced design techniques including automated analysis and design methods which will greatly improve capabilities for development of efficient, reliable, and cost-effective aerospace vehicles. To maintain and improve NASTRAN as the NASA standard structural analysis tool. Planned improvements are selected from those most needed by space shuttle contractors, aerospace industry users, and NASA Centers. Capabilities of final level of NASTRAN will be defined and plans established to accomplish this level by FY-78.

W76-70281 **506-17-22**
Langley Research Center, Langley Station, Va.
THERMAL/STRUCTURAL CONCEPTS FOR SPACE TRANSPORTATION SYSTEMS
R. R. Heldenfels 804-827-2042
(506-16-43)

The objective is to develop and evaluate thermal/structural concepts needed for efficient, reliable and cost-effective space transportation systems. Evaluate the integrity and aerothermal performance of surface TPS and control surface dynamic seal concepts by tests in the 8-foot High Temperature Structures Tunnel (8' HTST) and the Thermal Protection System Test Facility (TPSTF); maintain, operate and improve these facilities. Conduct analytical and experimental studies required to establish design technology for hot structures concepts for future space transportation systems such as fly-back boosters and SSTO vehicles.

W76-70282 **506-17-23**
Lewis Research Center, Cleveland, Ohio.
FRACTURE CONTROL TECHNOLOGY
R. H. Johns 216-433-4000

The major objective of this work is the technology development necessary for effective design, evaluation, and maintenance of structurally efficient and damage tolerant aerospace components. Both primary structure and propulsion system components are included. Fracture control developments oriented by the requirements of advanced space transportation systems will be emphasized. To achieve these objectives, programs structured to provide fracture control methodology, supporting test data, and definition of the NDE capability necessary to assure reliable, long life, and lightweight structures for reusable weight critical vehicle components will be conducted. A 100 mission reuse and 10-year operational life capability will be targeted as minimum objectives. Specific tasks will develop fracture control methods (including advanced fracture mechanics data and techniques when required) and provide failure criteria for structural metallic alloys. These objectives will be addressed by a program of interrelated in-house and contract activities.

W76-70283 **506-17-24**
Lewis Research Center, Cleveland, Ohio.
NONDESTRUCTIVE EVALUATION FOR SPACE STRUCTURES
R. L. Davies 216-433-4000
(506-17-12)

This program involves the development of advanced technology and adaptation of current technology to provide improved nondestructive evaluation (NDE) processes for future space vehicle structures. The main thrusts of this work will be the improvement of reliability and detection limits of current inspection methods for use with fracture control design methods for metallic structures and the development of the base technology required to determine the quality of composite materials and structures. This will include the use of NDE techniques in the study of failures in composites and the development of automated-signal processing and analysis methods to put inspection on a more quantitative basis. The program will be conducted through both in-house and contractual efforts.

W76-70284 **506-17-25**
Langley Research Center, Langley Station, Va.
ADVANCED METHODS FOR SHELL ANALYSIS
R. R. Heldenfels 804-827-2042

The objective is to provide advanced design techniques including analysis and design methods needed for efficient, reliable, and cost-effective space vehicles. The approach is to continue support of development of advanced computerized analysis of shell-of revolution structures using methods which are foolproof in requirements for user skills because of the use of integration (the 'field' method) for solutions rather than more numerically uncontrolled algebraic solutions. Continue support and improvement of analysis tools which determine linear/nonlinear stress behavior and vibration characteristics of two-dimensional shell structures. Apply analysis to critical agency problems as required. Study effects of imperfections in shell structures to generate more rational design procedures. In-house efforts will be focused on studying new solution techniques which will permit in-depth, practical modeling of critical areas of structure.

W76-70285 **506-17-26**
Langley Research Center, Langley Station, Va.
COMPOSITE SPACE STRUCTURES
R. R. Heldenfels 804-827-2042
(505-02-42)

The objective is to provide, through advances in the state of the art, efficient, cost effective structural concepts for future earth orbiting, planetary and deep space spacecraft and launch vehicles. Design concepts for ultra lightweight space panels will be investigated. Structural integrity of panels with surface densities of about one tenth of pound per square foot will be studied in laboratory tests. Methods of design for composite shell structures will be developed. Advanced concepts for cylindrical shells will be investigated. To save costs, the feasibility of conducting curved panel tests in lieu of full-scale shell structures will be investigated. Buckling tests on a series of curved panels and a limited number of large shell structures will be conducted.

W76-70286 **506-17-27**
Langley Research Center, Langley Station, Va.
FATIGUE AND FRACTURE OF COMPOSITE MATERIALS
R. R. Heldenfels 804-827-2042
(505-02-31; 743-01-01)

In-house and contractual research will concentrate on

developing engineering analyses which predict the fatigue lives and fracture strength of composite materials. Failure modes will be studied, and the relevant parameters which control failure modes identified. Specific studies include the analysis of stringer stiffened orthotropic sheets, tests of thermally cycled composite materials, and an extension of an engineering model of laminar fatigue to interlaminar fatigue.

W76-70287 **506-17-31**
Ames Research Center, Moffett Field, Calif.
PAYLOADS DYNAMICS
R. H. Petersen 415-965-5880
(505-02-21; 506-17-32)

The objective of this research is to provide improved prediction methods and data on the dynamic loads resulting from aerodynamic noise, and exhaust plume interactions with the flow field and the resulting effects on dynamic loads. The research on dynamic loads will include basic experimental studies of surface pressure fluctuations due to attached and separated boundary layers and shock waves at transonic, supersonic, and hypersonic speeds. Empirical formulae that predict the temporal and spatial characteristics of the nonsteady loads will be derived from these data.

W76-70288 **506-17-31**
Langley Research Center, Langley Station, Va.
PAYLOADS DYNAMICS
R. R. Heldenfels 804-827-2042
(506-17-32)

The objective is to provide dynamics technology for the shuttle development team to assist them in the design of the vehicle, and to reduce the cost of future space systems through improvement of payload vibration analysis. The approach is to continue development of technology to properly define the dynamic environment experienced by a payload during shuttle launch. A flight dynamic loads experiment will be defined for LaRC's LDEF (Long Duration Exposure Facility) shuttle payload. Efforts to understand how to analytically predict coupling of vibration behavior of individual components will continue. Major experimental efforts will be focused on studies of a model payload and carrier structure. Feasibility of mini-computer-controlled data acquisition and shaker control systems for dynamic simulations will be investigated. Model tests of coupled shuttle system will be completed and analyzed. Analytical correlation of data obtained on 1/8-scale models of the external tank and solid rocket booster structures will be investigated.

W76-70289 **506-17-31**
Goddard Space Flight Center, Greenbelt, Md.
PAYLOADS DYNAMICS
J. P. Young 301-982-4964

The overall objective is to reduce the cost and increase the effectiveness of structural evaluation and reliability demonstration services for spaceflight hardware. This objective will be approached through a study of means to improve the cost effectiveness of both test and analysis services. The above objective will be met during FY-76 by performing the following activities: (1) continued development of more cost effective test specifications for components, (2) development of cost effective alternate approaches to creating shuttle spacelab payload environmental test requirements, (3) development of analysis method to predict low frequency acoustic environment in the shuttle payload bay at lift-off, (4) development of approach to be followed in the generation of a NASA-wide shuttle payload general test plan/specifications, and (5) development of spacecraft past performance data from which cost versus risk tradeoffs can be made on future pre-shuttle and shuttle era programs.

W76-70290 **506-17-31**
Marshall Space Flight Center, Huntsville, Ala.
PAYLOADS DYNAMICS
R. S. Ryan 205-453-2481

The objective is to derive and develop space vehicle structural dynamic technology that will establish techniques and methods resulting in a more efficient design with a lower cost. More accurate methods of predicting dynamic loads and the response of the structural system will be developed. Also, improved methods for analytically calculating high-fidelity mathematical models of spacecraft and payloads will be devised. The following tasks will be undertaken to accomplish the objective: task 42, development of modified vibration test criteria for qualifying space vehicle components, task 51, methods for combining payload parameter variations with input environment, task 52, development of free field acoustic test technique, task 61, statistical iteration method development, and task 62, spacecraft structural response prediction and minimization.

W76-70291 **506-17-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PAYLOADS DYNAMICS
R. R. McDonald 213-354-6186

The principal objective of this five-year effort is to perform research and advanced development in structures and dynamics design, analysis, and testing in order to reduce the cost of future spacecrafts and shuttle payloads. Shuttle payload related activities are to be coordinated with OMSF. The research and advanced development plan coordinated with NASA headquarters and other NASA centers will be pursued. Wherever feasible, the tasks will use Viking Orbiter's existing load analysis, test data, flight data, and schedule data.

W76-70292 **506-17-32**
Langley Research Center, Langley Station, Va.
SHUTTLE DYNAMICS AND AEROELASTICITY
R. R. Heldenfels 804-817-2042
(506-17-31)

The objective is to provide dynamic and aeroelastic technology for the shuttle development team to assist them in design of the vehicle, and to reduce the cost of future space systems through improvement of spacecraft acoustic and vibrations analysis and test programs. Many of the previous studies in this area were oriented toward identifying potential problem areas requiring further research. Much of the current program is directed toward evaluation of identified potential problem areas, defining methods of alleviation, and validation of final design concepts with regard to dynamic loads and aeroelastic stability. The investigations will be primarily in-house with some contract support, and will make use of both analytical and experimental methods.

W76-70293 **506-17-32**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE DYNAMICS AND AEROELASTICITY
R. H. Petersen 415-965-5880
(506-17-31)

Wind tunnel test support and analysis will be provided to investigate transonic buffet (including aeroelastic effects), aerodynamic noise inputs and response, and flutter of a space shuttle vehicle. Rocket exhaust plumes will be simulated by cold jets so that static and dynamic loads can be measured in a realistic launch environment. The dynamic response of representative skin panels will be determined in wind tunnel tests which simulate the actual launch environment. The flutter of representative skin panels will be evaluated and a computer program for predicting the flutter of space shuttle type panels including boundary layer effects will be validated. Aeroelastic effects on the stability and control of the space shuttle will be determined using the FLEXSTAB computing program. Additional models will be tested as needed to investigate panel response, buffeting and flutter, and pressure fluctuations will be measured in regions of high intensity noise to evaluate aerodynamic noise inputs.

W76-70294 **506-17-33**
Goddard Space Flight Center, Greenbelt, Md.
STOP (STRUCTURAL-THERMAL-OPTICAL-PROGRAM)
H. P. Lee 301-982-5275

The objective of this RTOP is to advance multidisciplinary analysis capabilities by developing unified general computer programs in relevant technical disciplines. The purpose is to provide greater solution accuracy and to increase cost effectiveness by reducing the need to develop separate analytical models with the concomitant requirement for intermodel data transfer. Unified

approaches are particularly effective in cases such as space-borne telescopes where small thermally caused deflections can cause significant degradation. The approach is to develop a general purpose finite-element heat transfer computer program compatible with the structural version of NASTRAN. The results of the thermal deformation analysis are then used in another existing ray-trace computer program to evaluate optical or RF performance. The unified thermal-structural model simplifies the discipline interface and permits a virtually unlimited problem size. An analytical capability to assess the sensitivity of temperature variances due to uncertainties inherent in input values of system parameters is also included in this RTOP. Included in this current RTOP are efforts to provide capabilities to deal with heat pipe and phase change effect methods of precision temperature control, develop higher order elements to improve solution accuracy and efficiency, and automate portions of the program which currently require a long train of input cards. The approach is to develop the analytical methods to achieve these goals in-house. Implementation into a working program is to be accomplished by contract.

W76-70295 **506-17-34**
National Aeronautics and Space Administration, Washington, D.C.
SHOCK AND VIBRATION INFORMATION CENTER (SVIC)
Douglas Michel 202-755-2364

The SVic is a government and industry sponsored facility located at the Naval Research Laboratory that provides a focal point and source for shock and vibration information. It receives its support principally from DOD and NASA.

W76-70296 **506-18-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED IMAGING SYSTEMS TECHNOLOGY
R. V. Powell 213-354-6586

The long-term objective of this RTOP is the development of imaging system enabling technology to meet the anticipated requirements of future planetary imaging missions. The general approach includes the study of future missions as a source for the postulation of future imaging requirements, the study of current and projected imaging technology as a means of establishing a state-of-the-art baseline, and the implementation of specific technology development tasks to provide the desired enabling technology. The current objective is the development of solid state imaging sensor technology for both Mariner and Pioneer class spacecraft, based upon charge-coupled device (CCD) technology. These devices have the potential advantages of small size, reliability, scan versatility, geometric fidelity, magnetic cleanliness, and very high sensitivity. Furthermore, they are expected to lead to an integral solid-state camera (excluding optics) with major cost savings to future missions. A near-term target is to provide, by FY-77, a CCD imaging sensor with 10 to 100 times the sensitivity of the Mariner vidicon for outer planet flybys. The approach includes a three phase contractual program coupled to an in-house analysis and test program. The technology advances resulting from this RTOP are being applied to OSS camera development programs for Jupiter-Uranus flybys and Jupiter Orbiters, and to development of sensors for Large Space Telescope applications.

W76-70297 **506-18-12**
Langley Research Center, Langley Station, Va.
HIGH RESOLUTION SENSORS
J. E. Stitt 804-827-3745
(176-30-31; 683-10-00)

The objective of this research is to develop advanced sensors and sensor systems technology for remote and in situ sensing of the earth, aircraft, and spacecraft environments. Technology areas to be investigated are: (1) hydrographic LIDAR techniques for the measurement of chlorophyll a concentration, salinity, and turbidity of bodies of water; (2) continuously tunable infrared diode lasers for high resolution absorption and emission spectroscopy of low concentration atmospheric constituents; (3) miniature diode laser velocimeters for aircraft and spacecraft boundary layer gas flow field measurement; (4) ultrasonic sensors for particulate detection in turbid fluids; and (5) ultraviolet absorption sensors for smoke stack effluent monitoring.

W76-70298 **506-18-13**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMICAL HIGH RESOLUTION SENSORS
J. T. Williams 301-982-5095

The objective of this RTOP is the development of high performance astronomical sensors. In particular, we will investigate: an opaque photocathode camera, a photon counting TV using ICCD arrays, and development of large area CCD arrays as high resolution devices for future astronomical space missions.

W76-70299 **506-18-21**
Langley Research Center, Langley Station, Va.
ELECTRONIC DEVICES AND COMPONENTS
J. E. Stitt 804-827-3745
(520-71-01; 512-52-02)

The objective is to develop advanced electronic devices and components required for application in future aerospace missions. Analytical studies and laboratory investigations in selected areas of electronic materials and processes will be conducted and research contracts will be used to develop these materials and processes to provide new electronic devices and components. Those material and process technologies, with the potential for providing improved and reliable electronic performance in cost effective devices and components, will be emphasized. Current research efforts include the investigation of new materials and processes for developing improved infrared detectors, strain and heat flux sensors, and filament materials for calibrating mass spectrometers. Organic materials as a storage medium in optical mass memories and garnet films for magnetic bubble storage systems are investigated. Liquid crystal and light emitting diode modules for application in panel cockpit displays, charge coupled devices for buffer memory and filtering applications, and solid state photosensor arrays for planetary imaging and spectrometery are being developed. Graded band-gap materials are being investigated to develop solar cells with improved power conversion efficiencies. Material and device technology is being investigated for application in monolithic configurations for integrated optic data systems.

W76-70300 **506-18-22**
National Aeronautics and Space Administration, Washington, D.C.
ELECTRONIC DEVICE AND SYSTEMS SUPPORT
C. E. Pontious 202-755-3227
(506-18-21; 506-18-31; 506-18-32; 506-18-33)

The objective of this program is to provide effective coordination of NASA sponsored research and development efforts on electronic devices and systems with similar work supported by DOD and other government agencies. Through associate membership on the Advisory Group on Electron Devices and its constituent Working Groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R and D procurement activities, long range R and R requirements, complementary work in other government agencies, and forecasts of new technical developments.

W76-70301 **506-18-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
FIBER OPTICS FOR DATA TRANSMISSION AND PROCESSING
R. V. Powell 213-354-6586

The goal of the proposed effort is to apply the emerging technology of fiber optics and integrated optics to NASA needs, and to contribute to the advancement of the technology in selected areas. The initial effort, in collaboration with the Langley Research Center, is to define requirements for a selected application (shuttle payload), to identify the limiting technology, and to define the approach to be taken toward the construction of a flight experiment type of data-link for the shuttle payload. Other applications will be considered as the work progresses. The long term goal is to provide the technology for the application of fiber optics and integrated optics in a variety of space flight and ground applications in order to obtain benefits of lower costs, reduced weight, and improved immunity to noise pickup, electromagnetic interference and ground loops. During FY-76 the requirements study for the selected shuttle payload system will be completed and a laboratory

breadboard will be constructed having appropriate performance. A second application, probably an intercomputer data-link, will also be defined and requirements established for it.

W76-70302 **506-18-31**
Marshall Space Flight Center, Huntsville, Ala.
DESIGN, PROCESSING AND TESTING OF LSI ARRAYS
John M. Gould 205-453-3770
(506-18-32; 506-18-33; 180-17-55)

The objective is to improve product uniformity and performance, reduce the cost, size and power requirements of large scale integrated circuits (LSIC's) and hybrid electronic devices for all NASA applications. The approach is to provide the technology, techniques, equipments, and sources to ensure that long-life LSI arrays can be produced economically and consistently through the accomplishment of the following tasks: (1) Task 01: device technology; design and test software; (2) Task 02: LSI processing technology; (3) Task 03: controlled LSI processing techniques; (4) Task 04: hybrid microcircuit technology.

W76-70303 **506-18-32**
Marshall Space Flight Center, Huntsville, Ala.
SCREENING AND RELIABILITY TESTING OF MICROCIRCUITS AND ELECTRONIC PARTS
L. C. Hamiter 205-453-3770
(506-18-31; 506-18-33)

The objective is to develop approaches for assessing and assuring predictable long operating life of microcircuits and other electronic devices used in aerospace applications. A reliability study and test program is being conducted on solid encapsulated microcircuits in order to identify failure mechanisms associated with the designs, materials, and processes used in their fabrication. This study will also develop qualification, screening, and inspection methods necessary to assure the reliability of these devices in space applications. Programs are also being implemented to develop new and improved acceptance tests and inspections for electronic parts. Included in these efforts is a study to investigate the potential of using operating temperature cycling of microcircuits to screen poorly bonded internal interconnecting wires and defective die metallization. A test program is being initiated to determine the effectiveness of low temperature operating life tests to screen microcircuits and other electronic parts having complex metallization systems that may be highly susceptible to adverse reactions to minute amounts of chemical contaminations. Also, a program will be continued in the area of improving wafer level testing of microcircuit die used in hybrid and discrete microcircuits. This program is intended to significantly improve reliability and reduce the costly rework necessary using present techniques.

W76-70304 **506-18-33**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PREDICTABLE LONG-LIFE COMPONENT TECHNOLOGY
R. V. Powell 213-354-6586

The goal of this effort is to provide NASA with a microelectronics technology which will provide the reliability that is necessary to achieve the mission objectives of a wide range of future space missions including those involving unusually long flight times. The approach will be to thoroughly investigate those technologies which NASA will be utilizing on future missions and to identify the life limiting mechanisms inherent in the basic processes involved. Models will be developed of specific failure mechanisms. These models will be used in combination with test chip measurements to predict the probability of device failure, and their specific behavior under varying environmental stresses. This understanding will promote constructive feedback to the fundamentals of processing which will then further enhance device reliability. The near term objectives will focus specifically on standard MOS Technology and appropriate hybrid packaging techniques which will take full advantage of the MOS potential. Specific investigations of failure processes will center around: oxide breakdown, charge instabilities, metallization instabilities, and silicon defects. The work under this RTOP is being conducted in close cooperation with the MSFC to satisfy the specific NASA objective long life reliable circuit technology. Specific RTOP target objectives are: (1) by late FY-76 establish basic CMOS life prediction techniques which includes the known dominant failure mechanisms. These techniques provide for the inclusion of new failure mechanisms as they are identified and defined; (2) by mid-FY-76 complete the evaluation of thick vs. thin film packaging technology; (3) by late FY-76 report preliminary findings on CMOS accelerated tests; (4) by late FY-76 determine the effectiveness of wafer test circuits for predicting device reliability.

W76-70305 **506-19-11**
Marshall Space Flight Center, Huntsville, Ala.
INERTIAL COMPONENTS
B. F. Walls 205-453-5910
(909-10-31)

The objective is to continue technology development in the inertial sensor field. The major effort being on the ring laser gyro and in developing hybridized electronic packages peculiar to inertial sensors. Other sensors such as the dry gyro will be investigated. The laser gyro work supports the redundant strapdown inertial navigation system under development at MSFC. This system is presently baselined as the tug IMU. Work will be performed to advance the laser gyro basic technology and to evaluate candidate ring laser gyro performance characteristics. A continuing program in design and hybridizing the peripheral electronics required by inertial sensors will be continued. The work to be performed under this program is divided into four tasks: (1) laser gyro development; (2) dry gyro for strapdown systems; (3) investigation of strapdown sensor rebalance loops and system redundancy concepts; and (4) experimental studies of body-mounted gyroscope design.

W76-70306 **506-19-12**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED COMPONENTS FOR PRECISION CONTROL SYSTEMS
H. E. Evans 301-982-5194
(506-19-13; 506-19-14)

This task covers research, design and evaluation of cost effective advanced control and stabilization components and related control circuitry for precision pointing applications and long duration missions. Components and control systems for both earth orbital and interplanetary applications are included. For precise pointing systems, prototype components and control systems will be developed with: (1) broader range dynamic control capability, (2) greater efficiency, and (3) increased reliability by elimination of life-limiting elements of attitude control components. Component technology advancements are utilized which include the technical breakthroughs in the areas of electronic commutation, magnetic suspension techniques and microprocessors. These concepts are integrated into cost effective precision component designs such as long life magnetic bearings, isolation systems, multiaxis control and advanced motors and actuators. Speed and position control systems compatible with these new concepts also form part of this work. Advances in the above areas of technology are supporting Applications Technology, Planetary, Earth Orbiting systems, Shuttle and have general applicability throughout the Guidance and Controls area.

W76-70307 **506-19-13**
Langley Research Center, Langley Station, Va.
ADVANCED SPACECRAFT AND EXPERIMENT CONTROL SYSTEMS
J. E. Stitt 804-827-3745
(909-74-35)

Technology will be developed to permit the design of cost effective spacecraft and experiment control systems for earth orbital missions. Simulations will be made of new and existing control concepts for earth orbital vehicle/missions in order to determine required system and component performance. Effective system configurations, low-cost system integration, multipurpose operation, and component standardization will be used to reduce system and component costs while achieving required performance. Control software and hardware needs will be defined and development efforts undertaken. Critical hardware elements will be carried through laboratory developments to establish feasibility. This effort is directly coordinated with GSFC, JSC, MSFC, and

JPL. GSFC developed components will be integrated into Langley control actuator hardware.

W76-70308 **506-19-14**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EXTENDED LIFE ATTITUDE CONTROL SYSTEMS (ELACS) FOR UNMANNED PLANETARY VEHICLES
Robert V. Powell 213-354-6586
(186-68-54)

The long range objective of extended life attitude control system (ELACS) is to develop and demonstrate a spacecraft control concept that is applicable to a wide range of unmanned, earth orbital, planetary, and shuttle programs. In combination, these missions demand longer life, improved accuracy, lower weight, less power, and greater cost effectiveness. Specific program targets are: (1) by FY-76, complete development of flex. body control analysis technology for predicting induced angular rates of planetary science instruments to better than 1 sec/sec; (2) by mid FY-77 mechanize and test a breadboard programmable attitude control electronics with fault tolerant capability with a life potential of greater than 8 years; (3) by end of FY-77, develop and demonstrate a long life dry gyro inertial reference unit (DRIRU) to achieve a weight savings of 45%, and a cost reduction of 43%, as compared with the present Mariner/Viking dual IRU; (4) derive and demonstrate a final design by early FY-78 of control filters and state estimation algorithms for fault tolerant programmable electronics to meet science pointing requirements for rate settling to 2 sec/sec in less than 10 seconds; (5) by early FY-78, develop and demonstrate an engineering model long life reaction wheel with life potential greater than 8 years; (6) by mid FY-78, develop and demonstrate an engineering model star tracker for economical long life attitude reference (STELLAR) with a cost saving 50% (i.e., 1,200k reduced to 500k) of a typical Mars orbiter program; and (7) by FY-79, mechanize and test a breadboard extended life attitude control system (ELACS) with a 0.01 deg pointing accuracy and a lifetime potential of more than 10 years with functional redundancy.

W76-70309 **506-19-15**
Ames Research Center, Moffett Field, Calif.
VIDEO INERTIAL POINTING SYSTEM FOR SHUTTLE ASTRONOMY PAYLOADS
J. V. Foster 415-965-5083
(356-41-06)

The objective of this RTOP is to develop and flight demonstrate an attitude reference system that will satisfy the acquisition and pointing requirements of shuttle attached astronomy payloads, including the shuttle infrared telescope facility (SIRTF). The video inertial pointing (VIP) system will provide computer generated error signals for three-axis stabilization and pointing of the astronomical telescope. In addition, system outputs will drive a display for use in star field/target identification and manual pointing control. The star field sensed by a coarse and a fine video sensor aligned to the optics of the telescope will provide the basis for a three-axis attitude reference. The relative positions of two or more stars in the field will be combined with the outputs of a triad of rate integrating gyros (RIG's) in an onboard digital computer to generate pointing and stabilization error signals. The outputs of the video sensors will also drive a CRT display at the operator's console to facilitate quide star/target acquisition and manual pointing of the experiment. The VIP system will be developed in several stages with each stage culminating in a flight evaluation on the Ames Infrared Balloon Borne Telescope (AIROscope). Analysis and simulation will be used to develop the multiple star processing and gyro filtering capability. An advanced CCD sensor will be developed by JPL for use in the flight evaluations.

W76-70310 **506-19-16**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EXPERIMENT POINTING MOUNT
R. V. Powell 213-354-6586
(506-19-14; 186-68-54)

The shuttle instrument pointing system currently being proposed by ESA does not fully satisfy all user requirements or meet all desirable vehicle and payload constraints. The objective of this effort is to formulate an experiment pointing technology (EPT) approach that will meet Spacelab payload needs in a cost effective manner. An ad hoc Working Group will be established to develop user requirements that are applicable to payload control parameters. Alternate and complementry pointing systems presently being suggested and studied will be considered for their individual technical approach. The activities will draw upon existing studies of experiment pointing subsystem requirements and suggestions from the steering group Space Transportation System - Payload Requirements and Analysis Group (SPRAG).

W76-70311 **506-19-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GUIDANCE AND NAVIGATION FOR UNMANNED PLANETARY VEHICLES
R. V. Powell 213-354-6586
(186-68-74; 310-10-60)

The objectives are to derive and verify advanced navigation techniques incorporating new ground and on-board measurements and software into a navigation system which minimizes trajectory correction delta V requirements, enables efficient gravity-assists, and permits precise scientific observations resulting from improved field of view delivery capability, increased mission opportunities, and lower operational cost for future exploration. Specific targets are: (1) by FY-76, demonstrate the ability of S-X band multi-frequency and multi-station radiometric data to reduce effects of dominant error sources by a factor of ten and yield increases in accuracy, reliability, propellant savings and mission design flexibility; (2) derive and validate in-flight approach guidance techniques which yield 25 micro-radian measurement accuracies in 6-hour turn around times and can allow up to 50% payload increases through on-board propellant savings for outer planet missions; with satellite/star scene and CCD measurement technologies to be available in FY-77; (3) by FY-79, demonstrate outer planet satellite ephemerides programs, which improve present (FY-74) ephemerides by factors of 5-20 and allow a factor of 50 reduction in the time required to generate satellite trajectories resulting in project cost savings and increased mission operations flexibility; (4) by FY-80, demonstrate in the laboratory an optical navigation system using simulated flight data processing which reduces the measurement processing time from the 6 hours currently required to 2 minutes while retaining the accuracy to within 20%; and (5) by FY-86, design and validate in flight a fully autonomous system with the capability of on-board flight path control to 1 km within two minutes of final measurement for small body rendezvous or flyby missions.

W76-70312 **506-19-31**
National Aeronautics and Space Administration, Washington, D.C.
ARTIFICIAL INTELLIGENCE
W. Gevarter 202-755-3227
(506-19-32)

The objective of this RTOP is to improve our ability to manage large amounts of data, to effectively utilize sensed information, and to provide more efficient methods for processing information. Near term targets include development of automated problem-solving systems and techniques for machine perception and analysis of scenes. The technical approach is to develop computer models which simulate intelligent system operations such as perception, question-answering and learning and test these models with various real or approximately real functional problems. The results will provide guidelines for the development and exercise of autonomous or robotic systems such as the JPL robot Rover project. The work will be performed through a series of research grants and contracts with academic and industrial laboratories recognized for their competency in automated information systems R and D.

W76-70313 **506-19-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ARTIFICIAL INTELLIGENCE FOR INTEGRATED ROBOT SYSTEMS
R. V. Powell 213-354-6586

The long-range objective is to establish a technology base in robotics and semiautonomous control of unmanned machines

or vehicles to support lunar and planetary surface explorations. The results of the work will also be applicable to other remote systems, automated fabrication facilities, and other systems and activities of importance to NASA and the nation as a whole. At JPL, a robot roving vehicle is being assembled to demonstrate semiautonomous operations, provide practical tests of machine intelligence concepts, define research requirements, and develop design guidelines for system applications. During FY 1976, a four-wheeled vehicle, a manipulator, a laser rangefinder, stereo TV, and navigational and proximity sensors will be integrated with each other and with a computer system, and tethered operations will begin in an indoor laboratory. In FY 1977, this breadboard system will be extensively tested to evaluate controlling software, system operational procedures, and strategies for coordinating sensors and effectors to accomplish such tasks as moving from one location to another and picking up a rock or tool without operator assistance. In FY 1978, semiautonomous operations of an untethered vehicle in increasingly complex outdoor settings will be demonstrated. In FY 1979 and subsequent years, new concepts in manipulators, sensors, and control strategies will be incorporated and evaluated; studies will be made to determine the balance between autonomous control and interactive (man-machine) control for the efficient conduct of remote operations; and data and engineering criteria will be provided to guide the design of lunar and planetary rovers and other remotely controlled machines.

W76-70314 **506-20-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED DIGITAL DATA SYSTEMS FOR DEEP SPACE
R. V. Powell 213-354-6586

The goal of this work is the development of advanced technology for integrated spacecraft data systems including the functions of control, data acquisition, data processing, and data storage. Work during FY-76 will focus on three objectives: (1) development of a unified data system (UDS), for missions having launches after 1977; (2) data compression and processing research; and, (3) development of a magnetic bubble buffer memory. A specific UDS design was achieved in FY-75 and a breadboard test and evaluation is planned for FY-76. The effort encompasses the consolidation of hardware, the application of microprocessors, simplification of software, and incorporation of fault tolerance. The justification of a new UDS design is based on a cost savings goal of approximately $1300K per mission for the mission set listed in 15.B of this plan. The $1300K per mission saving represents $500K saving in flight software costs, $400K saving in support equipment and support software costs, and $400K saving in hardware costs due to the common processor and standardized S/C interfaces. Research will continue on tasks pertaining to advancement of data compression technology. The main emphasis will be directed toward planetary optical imaging and radar imaging applications. The work will include investigation of incorporating pattern recognition into the control elements of the RM2 compression algorithm, simulations with the basic RM2 algorithm to enable investigation of image fidelity considerations, and study of RM2 hardware implementation issues over a wide range of input data rates. The architecture for a static memory using bubble technology was completed in FY-75, and a functional breadboard was constructed using commercial bipolar memories. During FY-76, breadboard testing will be completed. The procurement of a bubble memory building block is scheduled for mid-FY-76 with functional and environmental tests to follow.

W76-70315 **506-20-14**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATED DATA HANDLING TECHNIQUES AND COMPONENTS (HIGH CAPACITY DATA SYSTEMS)
David H. Schaefer 301-982-5184
(656-21-01)

The focus of this RTOP is to develop methods of on-board analysis of image data generated by earth observation and other image sensing missions. Under this RTOP, parallel image processing systems are being developed. Such systems process all points of an image simultaneously. Priority is being given to the development of a digital type of parallel image processing known as a tse computer. Such computers are two dimensional analogs of conventional digital computers. These computers will process from sixteen thousand to one million points simultaneously. It is the aim of this RTOP to develop computing systems suitable for spacecraft on-board use that have an effective bit rate of 10 to the 12th power bits per second. Real time image processing systems that utilize coherent optical phenomena are also being developed.

W76-70316 **506-20-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROMINIATURE TRANSPONDER DEVELOPMENT
R. V. Powell 213-354-6586
(186-68-53; 506-20-22)

The objectives of this RTOP and OSS RTOP 186-68-53 are to jointly develop microwave radio transponder techniques, components, and subsystem technology required for NASA planetary missions in the period 1977 to 1982. Particular emphasis will be placed on substantially reducing the cost of transponders while improving performance capability, reliability, and lifetime and reducing size, weight, volume, and power consumption. The key element of the development is a microminiature multimission transponder (MMT) consisting of an S-band receiver and an S/X-band exciter assembly utilizing such advanced devices as beam leaded RF-IC's, surface acoustic wave filters (SAWF) and ceramic substrates. Accomplishments to date include: (1) the demonstration of technology readiness of a discrete component-printed circuit board version of the MMT by the end of FY-74 (this model became the baseline design for the MJS77, Pioneer Venus and B-Sat). This version has the following advantages over the Viking Orbiter design: an order of magnitude improvement in differential phase and group delay stability; and reductions of 35% in per unit cost; 72% in power consumption; 60% in volume; and 50% in weight. (2) The development, fab and evaluation of a set of SAWF's on quartz substrates (for very low TC necessary to reduce phase delay variations) by the end of the third quarter of FY-75. (3) The development, fab and evaluation of abreadboard version (beam leaded components in non-hermetic ceramic submodules) of the MMT by the end of FY-75. By the end of FY-76 microminiature brassboard assemblies and modules will have been tested to type approval and qualification test levels to demonstrate the technology readiness for flight missions beginning in 1979 which has the following advantages relative to the discrete component version: A doubling of mission life potential (adequate for 10-year missions without additional redundancy); and reductions of greater than 50% in weight and volume.

W76-70317 **506-20-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE COMPONENTS AND TECHNIQUES
R. V. Powell 213-354-6586
(506-20-21; 650-10-15)

The long range objectives of this RTOP are to (1) devise, analyze, develop, and test new telecommunication subsystems which are needed to meet the requirements of the deep space exploration mission set for the next decade, (2) investigate means of increasing the performance and decreasing the cost of existing subsystem designs, and (3) better understand the interaction of the telecommunication system with other spacecraft and ground systems in order to ensure that proper emphasis and direction is given to future system requirements and designs. The objectives of the FY-76 efforts are: (1) investigate advanced digital radio technology and components in microminiature form that will substantially reduce the cost of spacecraft radio, telemetry, command, navigation, and radio science functions while improving performance capability and flexibility, reliability, and life time; (2) begin development of an active antenna pointing system for use with antennas on the order of 15 meters at X-band frequencies, and steer the antenna R.F. beam electronically over the range of the attitude control system deadband; a near term objective is to develop an electronic array feed pointing system capable of working with a 3.6 meter antenna over a 2 degree range; (3) develop efficient techniques for determining the far field properties of large antennas from near field measurements, and provide analytical tools for designing and predicting the properties of array/reflector configurations; (4) analyze the effects on

electromagnetic waves propagating through dispersive media, and construct turbulence models for the solar corona and planetary atmospheres; and (5) investigate coding and modulation techniques which can be used to improve the efficiency of deep space microwave communications. The approach taken for all these efforts involves tradeoff studies, analysis, simulation, breadboard evaluation, and system testing.

W76-70318 **506-20-23**
Lewis Research Center, Cleveland, Ohio.
MICROWAVE AMPLIFIER TECHNOLOGY
R. E. Alexovich 216-433-4000
(643-40-10; 643-60-01)

To advance the state-of-the-art of microwave power amplification for space and terrestrial applications above one GHz will be investigated. To achieve this objective, research and technology development programs will be undertaken on microwave amplifiers, high current density electron emitters and high power microwave passive components. Studies and investigations of space-earth propagation and interference will be undertaken to guide high power communication component and subsystem investigation. Specific techniques such as multi-stage depressed beam collection and beam refocusing for linear amplifiers are among promising techniques being investigated in addition of rf circuit and electron gun optimization studies.

W76-70319 **506-20-24**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE NEAR EARTH DATA TRANSFER AND TRACKING
F. J. Logan 301-982-4901

The objective of the work under this RTOP is to achieve technological advances in data transfer and tracking systems in order to satisfy the demanding communication requirements for future space flight projects, such as space shuttle, earth observation satellite program and TDRS. The capability and performance requirements on the communication links for these advanced projects are characterized by high data rates (up to 200 Mb/s) simultaneous multi-link operation, and reliable long life operation. The attainment of these parameters requires technological advances in spacecraft techniques and hardware. High power efficient solid-state amplifiers at Ku-Band will be developed. These advances will be utilized in the development of a high data rate spacecraft transmitter package capable of direct communication to ground or to a data relay spacecraft. Previous work under this RTOP has verified that small, lightweight spacecraft low-noise parametric amplifiers are achievable in the existing NASA frequency bands. The future goals in this discipline are: improve overall power efficiency and reliability in existing designs, and prepare for future applications in both communications and microwave instruments by development of a space qualified parametric amplifier in the 35-40 GHz range.

W76-70320 **506-20-26**
Goddard Space Flight Center, Greenbelt, Md.
MILLIMETER WAVE COMPONENT DEVELOPMENT
J. L. King 301-982-5702
(650-60-11)

The objective is to develop millimeter wave component technology in the 50-200 GHz frequency range for use in advanced communications and sensor systems. Radiometer systems will be fabricated at 94 and 183 GHz to measure atmospheric losses by means of sun tracking and sky temperature inversions. Gallium arsenide Schottky barrier mixers and solid state impatt local oscillators will be developed to function as the front ends of these radiometers. This mixer performance will be compared with harmonic mixing to measure loss of performance due to harmonic mixing. After the development of mixer/local oscillator is complete, it will be installed in the 183 GHz radiometer to improve the existing systems performance. At this point, work will be started on the 94 GHz mixer using a 92 GHz fundamental frequency impatt local oscillator. Plans for this program are divided into three areas (1) components and techniques development, (2) system development, and (3) propagation experiments. During FY-76 components and techniques will be emphasized at 94 and 183 GHz, but in subsequent years systems and propagation experiments will become equal in importance. Radiometer systems will be developed to measure atmospheric losses from the gound and from high altitude aircraft flights for use in communications systems modeling and meteorological sensing of water vapor and precipitation. The first years component development effort will include improving the performance of mixers in the 183 GHz and 94 GHz frequency bands and developing solid state local oscillators for receiver systems in the same bands. Performance goals include achieving an 8 dB noise figure at 183 GHz and a stable 5 milliwatt oscillator at 183 GHz.

W76-70321 **506-20-31**
National Aeronautics and Space Administration, Washington, D.C.
OPTICAL DATA TRANSFER RESEARCH
C. E. Catoe 202-755-3227

This program of research is directed toward providing NASA with the fundamental tools and methods needed for the development and analysis of new types of lasers and laser devices that are applicable to future planetary, earth observations, and data relay missions. The activities addressed in this program will result in the advancement of laser technology in the areas of optical communications and tracking, optical processing and spectroscopy. This program will advance the optical laser technology by means of two research grants: one at the Massachusetts Institute of Technology which is concerned with the quantum aspects of optical communication, and the second at Stanford University that is concerned with development and understanding of laser phenomena.

W76-70322 **506-20-32**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL DATA TRANSFER SYSTEMS
J. H. McElroy 301-982-5608

NASA flight missions in the 1980's and 1990's will need high capacity data transfer systems. This RTOP is for the development of the technology to provide 300 Mbps and above data transfer terminals for space-to-space-to-ground relay links. The CO2 laser offers the best promise to meet these requirements and laser heterodyne systems using this laser are being developed under this RTOP. Theoretical, analytical, and trade-off studies are conducted to establish system parameters. Research and development is carried out to advance the state-of-the-art critical components such as waveguide lasers, infrared mixers, modulators, modulator drivers, and current regulated high-voltage power supplies needed for the laser discharge tubes. Acquisition and tracking techniques are being developed for spacecraft terminals. First-of-a-kind subsystems are assembled into engineering models in spacecraft configuration. Systems are evaluated in the laboratory and in test chambers to determine system performance parameters, such as bit error probability, receiver sensitivity, laser stability, and tracking errors (spatial and frequency).

W76-70323 **506-20-33**
Goddard Space Flight Center, Greenbelt, Md.
GEOPHYSICAL MEASUREMENT TECHNOLOGY
M. W. Fitzmaurice 301-982-4948
(645-40-01; 161-02-01; 653-01-01)

This RTOP is to provide the technology necessary for the development of precise space-to-space and space-to-ground-to-space laser range/range rate systems. Specific objectives are: (1) to develop the component and subsystem technology to advance the state-of-the-art in ground based laser ranging systems to the 5 cm level in FY/75-76 and to the 2 cm level in 1978, and (2) to develop the flight qualified components for a spaceborne laser terminal with 2 cm/.003 cm per second range/range rate precision. This spaceborne terminal is to be tested at the engineering model level in 1979-80 and flight tested on a 1980-81 shuttle mission. This RTOP interacts closely with RTOP's 161-02-01 and 653-10-01-03 in the development of ground-based systems and interacts closely with 645-40-01 in the development of the spaceborne systems. The four major tasks within this RTOP are: (1) advanced receiver development, (2) flight qualified Nd:YAG laser development, (3) high/accuracy tracking and control systems development, and (4) CO2 laser

tracking systems. During FY-76, Task 1 will emphasize the optimization of existing avalanche photodiode detectors for the short pulse ranging receiver application and will initiate the development of a swept image converter receiver for next generation systems. Task 2 will initiate the development of a 0.2 ns pulse laser for the 2 cm ranging systems and will continue the development of CW laser pumps for range rate systems. Task 3 will develop and demonstrate the techniques of open-loop satellite tracking at the 20 arc-second level and Task 4 will continue the feasibility analysis of CO2 laser tracking systems.

W76-70324 **506-21-10**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LIQUID ROCKET COMPONENT TECHNOLOGY
D. A. Petrash 216-433-4000

The general objectives of the programs conducted under this RTOP are to provide the technology for improvements in performance and reusability of liquid rocket components and subsystems. Experimental and analytical programs will be conducted to develop (1) low cycle thermal fatigue and heat transfer technology for reusable thrust chambers, (2) advanced thrust chamber technology using unconventional nozzles, (3) improved fabrication techniques for thrust chambers and (4) reduced gravity fluid acquisition and transfer systems. In the area of reusable thrust chamber technology, efforts will be devoted to obtaining fundamental fatigue data, developing the analytical capability to predict thrust chamber life and testing materials or new designs in an inexpensive thrust chamber simulator. Advanced heat transfer techniques will also be applied to ease the severity of the thermal load of high performance thrust chambers and improved fabrication techniques involving sputtering and electroforming will be evaluated to produce better, more reliable thrust chamber hardware. Unconventional nozzles will be investigated to provide more flexible design options, low pressure solutions to advanced engines, and high area ratio, high performance thrust chambers in a minimum size envelope. Low gravity fluid system studies will investigate critical characteristics and components for in-orbit fluid acquisition and transfer.

W76-70325 **506-21-11**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LIQUID ROCKET SYSTEMS TECHNOLOGY
John W. Gregory 213-433-4000
(909-75-03; 506-21-12)

Analytical and experimental efforts are being pursued to provide technology required for advanced reusable hydrogen-oxygen space propulsion systems, such as the space tug. Although much of the MPS technology is applicable to aerospike engines, the effort thus far, has been primarily directed toward bell nozzle type engines. In FY-76, the program will be expanded to include technology directly applicable to annular throat, aerospike type engines. In the bell nozzle type engine area, the effort is directed at developing the technology for small, high-pressure, reusable, pump-fed, staged-combustion cycle hydrogen-oxygen rocket engines. The work, which started in FY-72 and will carry through FY-77, is concentrating upon critical component technology for a 20,000 lb. thrust engine operating at a chamber pressure of 2000 psia. The component technology programs are in the turbomachinery and thrust chamber areas. If the FY-77 new initiative is approved, the components developed in these technology programs will be assembled into a powerhead breadboard assembly (PBA). Tests will be made to assess engine and component adequacy, capability and operating characteristics. A preliminary design study of the PBA will be conducted in FY -76 to enable assembly of the existing components. In the aerospike engine area, effort will be directed at determining the performance, regenerative cooling capability and the weight potential of an advanced, hydrogen-oxygen, aerospike thrust chamber for possible application in the main propulsion system for the space tug.

W76-70326 **506-21-12**
Lewis Research Center, Cleveland, Ohio.
REUSABLE CRYOGENIC STORAGE AND TRANSFER
John W. Gregory 216-433-4000

The work conducted under this RTOP will provide the technology required for the effective design and fabrication of reusable cryogenic thermal protection and fluid transfer systems. This work will be conducted on thermal protection systems designed to meet the problems associated with the changing environments experienced during a typical flight cycle by a reusable high energy upper stage. Work on a purged multilayer insulation system will be continued. Experimental evaluations will be conducted on the several baseline TUG multilayer insulation systems that have been proposed to demonstrate their performance under cyclic environmental conditions. Work will continue on a high performance load bearing insulation that is capable of providing performance approaching that of uncompressed MLI while still providing all of the advantages of an evacuated system without the attendant weight penalty usually associated with rigid vacuum shells. Experimental and analytical studies will be conducted to optimize multilayer insulation by selectively varying thickness and shield emissivity. The effort on fluid transfer systems will be applied to evaluation of the use of composite materials for the fabrication of engine feed lines, vent lines, pressurization lines, valves, and fittings. Designs will be evaluated to provide lines that are lightweight, have low axial heat conduction, and provide rapid chilldown.

W76-70327 **506-21-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LONG-LIFE ADVANCED PROPULSION SYSTEMS FOR PLANETARY SPACECRAFT
P. J. Meeks 213-354-2546
(506-21-51)

The objective of the work proposed in this RTOP is to provide for the advanced development of key liquid feed assembly components and the rocket engine assembly for advanced liquid propulsion systems that will be used on planetary missions. Specifically, in FY-76, fabrication of two each of propellant shutoff and isolation valves will be completed and the design of a remotely actuated fluorine fill valve will be initiated. Fracture toughness testing and impact testing on one heat of Ti6Al-4V will be completed. Additionally, the investigation of a fluorine-compatible foam insulation will continue. In order to finalize the baseline thrust chamber, a contract will be issued to design two ablative thrust chambers. The design will be based on the results of Contract NAS7-304 entitled Chamber Technology for Space Storable Propellants. From the design drawings, one engine design will be selected and two chambers will be fabricated and tested at C-stand at JPL's Edward Test Station. Concurrent with this effort a high-performance injector will be fabricated and tested. Systems studies will continue evaluation propulsion system configurations including structural and thermal support, based upon information generated from the valve and engine work. Main emphasis will be on the design of a blowdown propulsion system.

W76-70328 **506-21-30**
Langley Research Center, Langley Station, Va.
THE CHEMISTRY AND ATMOSPHERIC INTERACTIONS OF EXHAUST CLOUDS FROM ROCKET VEHICLES
E. S. Love 804-827-2893
(180-72-50)

The objective of this research is to develop a basic understanding of the chemistry of exhaust clouds from rocket vehicles and interactions of the exhaust clouds with the atmosphere including precipitation. Although the initial composition of the rocket exhaust is known at the SRM exit plane, it is of little use in determining the ultimate chemical and physical distribution of these products in the atmosphere, or on the ground. The chemical composition of the exhaust cloud changes continually; rapidly at first as a result of high-temperature reactions with atmospheric species and nucleation of condensible species, and then more slowly as a result of both ordinary and photochemical gas and condensed-phase reactions, gaseous diffusion, droplet growth and evaporation, and various other interphase and transport phenomena. Thus, a complete chemical characterization of the resulting exhaust cloud as a function of propellant, atmospheric conditions, and time is needed to properly assess the environmental impact of the exhaust products. The results of the research

proposed herein will provide a critical part of the technology base required by NASA to develop and substantiate the environmental impact statements for future NASA rocket launches.

W76-70329 **506-21-31**
Langley Research Center, Langley Station, Va.
ADVANCED PYROTECHNIC/EXPLOSIVE SYSTEMS TECHNOLOGY
E. S. Love 804-827-2843

The overall objective is to develop and demonstrate technology for pyrotechnic systems to meet expanding aerospace flight requirements. Experimental programs will be conducted to develop engineering design guidelines to meet pyrotechnic system requirements, such as safe, reliable initiation, stable pyrotechnic and explosive materials, and the selection and sizing of propellant loads to accomplish a variety of mechanical or chemical functions. Ignition, combustion, and energy delivery mechanisms will be studied through the use of advanced performance monitoring techniques and systems, developed to simulate the actual flight working conditions and requirements. Developmental studies will include: the selection and evaluation of a variety of safe, electrically nonconductive first-fire propellants, as well as high-performance gas generating propellants, and the expansion of the NASA Langley Research Center explosive seam welding technique to meet advanced aerospace fabrication requirements.

W76-70330 **506-21-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED SOLID PROPULSION AND PYROTECHNIC CONCEPTS
P. J. Meeks 213-354-2546
(506-21-52)

The long-range objective of this RTOP is to develop and demonstrate solid rocket propulsion and pyrotechnic advanced technology that can be applied to: (1) reduce cost, improve performance, and improve reliability of existing concepts, and (2) provide new concepts for future NASA missions, in which existing propulsion and pyrotechnic mechanisms cannot be used to satisfy the mission peculiar requirements. A comprehensive approach, which employs analytical and experimental investigations, in both in-house and subcontracted modes, will be utilized to select, develop, and demonstrate the required advanced technology. Work also will be accomplished to provide solutions to solid rocket motor operational and design problems. This plan is the major element of the OAST Level 4 program on Low Cost Solid Propulsion. The efforts included in this RTOP are: Waste Propellant Disposal with Component Salvage and Recycle; Modification of Aluminum Fuel by Surface Oxidation; Heat Sterilizable Propellants; Gas Dynamics of High Back Pressure Propulsion; Laser Beam Chemical Explosives Interaction; Long Term Storability of Solid Propellant Motors; High Energy Upper Stage Restartable Solid Rocket Demonstration, Advanced Propulsion Module Motor Technology; Pyro and Explosive Technology; Squib Pyrotechnic Material; and Solid Propellant Combustion.

W76-70331 **506-21-33**
Langley Research Center, Langley Station, Va.
SOLID BOOSTER EXHAUST
E. S. Love 804-827-2893

The objectives of this research are to examine and to demonstrate the effectiveness of chemical agents and delivery systems in neutralizing the acidic effluents emitted in the troposphere by the solid propellant boosters of the space shuttle. The Environmental Statement for the Space Shuttle Program (July 1972) states that operational constraints will be imposed on space shuttle launches to eliminate the possibility of unacceptable hydrogen chloride concentrations in the troposphere. The possibility of the delay of launches due to the possible unacceptable environmental impact of hydrogen chloride would be cause for concern. This research will attempt to demonstrate that the hydrogen chloride emitted in the troposphere can be neutralized by a cost effective system and that the potential toxic hazards due to the gaseous hydrogen chloride can be removed and the possibility of an acid rain eliminated. Several potential neutralization agents have been investigated and it has been calculated that it is chemically possible to neutralize all of the hydrogen chloride by the addition of chemical agents to the exhaust cloud. The various methods of delivering the agents to the exhaust cloud include adding to the deluge water presently used to cool the launch complex, spray entrainment in the ducted exhaust gases at ground level and airborne delivery using aircraft similar to those employed in forest fire control. A feasibility study and demonstration of the system is necessary before the decision to proceed with the design of the modification and/or additions to the launch complex.

W76-70332 **506-21-40**
Lewis Research Center, Cleveland, Ohio.
LASER PROPULSION TECHNOLOGY
D. L. Nored 216-433-4000
(506-25-51)

The objective of this program is to evaluate the concepts and establish the potential feasibility of laser propulsion by 1980. The program will investigate propulsion concepts and systems based upon the energy being transmitted by a laser beam from a remote station. Space, aircraft and earth-based laser systems for potential NASA and military application will be included. A broad technology base will be developed for realistic appraisal of systems, mission application and design. Efforts will concentrate on most appropriate laser systems, beam transmission, laser-beam receiver systems, efficient conversion of laser beam energy to sensible propellant enthalpy, and viable thruster design. The program approach includes: (1) identification of laser energy absorption mechanisms in propellants; (2) performance of components and system studies (synthesis, definition, design, tradeoffs, and problem area identification); (3) evaluation of potential mission possibilities; (4) design, fabrication and evaluation of laser thruster concepts; and (5) investigation of optimum wavelengths and lasers for propagation, absorption by propellant and compatibility of optics systems.

W76-70333 **506-21-41**
Lewis Research Center, Cleveland, Ohio.
ATOMIC AND METALLIC HYDROGEN
Gerald V. Brown 216-433-4000

The objectives are to produce and store hydrogen in each of two different monatomic forms, metallic hydrogen and spin-aligned atomic hydrogen. Either form would store an energy of approximately 50 K cal/gram with respect to the molecular state. Such stored energy would be recoverable by allowing reversion to the molecular state. Superconductivity of metallic hydrogen will be studied, and other properties of both new allotropes will be determined. High pressure devices capable of producing a few megabars will be developed to compress hydrogen to about 15 times the ordinary molecular solid density and thus cause the predicted transition to the metallic state. Hydrogen dissociated to atoms by various means (electric discharge, photolysis, and irradiation) will be stored at temperatures below 2 K and in magnetic fields of 2 to 10 tesla to paramagnetically align the electron spins and prevent formation of the molecular bond. Matrix storage of H in H2 will be investigated to determine maximum H concentration possible as a function of temperature (below 2 K) and magnetic field.

W76-70334 **506-21-42**
Langley Research Center, Langley Station, Va.
PROPAGATION STUDIES USING EXTENDED WAVELENGTH RANGE OF HIGH POWER LASERS (PROPULSION NEW HORIZONS)
E. S. Love 804-827-2893
(506-25-55; 506-18-12)

The objective is to extend the wavelength range of high power lasers (CO2, CO, DF, HF) for improved atmospheric transmission and to evaluate their potential use in spacecraft experiments. For this purpose high power/high pressure lasers are being developed which permit tuning across pressure broadened laser lines. The tuning characteristics and mode structure of a high pressure (approximately 5 atm) photopreionized pulsed CO2 laser with medium pulse energies (approximately 1/10 Joule), recently developed under contract, will be evaluated with a laser heterodyne spectrometer and laboratory

transmission cells. High power/high pressure CO2 lasers will be developed with high resolution tuning at higher pulse energies (greater than or equal to 1 Joule) and high pressure operation of other laser types (CO, DF, HF) investigated. The feasibility of high pressure CW operation of high power lasers will be evaluated. The results will be coordinated with laser propulsion studies at other NASA centers and related DOD studies.

W76-70335 **506-21-43**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NEW HORIZONS IN PROPULSION
P. J. Meeks 213-354-2546

The objective of this program is to identify and conduct research on new concepts in propulsion which offer significant improvements over systems that now exist or are in development when these new concepts are applied to a variety of future propulsion requirements. The approach is to define the concepts in sufficient detail to allow initial applications analyses to be made and then to evaluate the applications. These concepts are compared with current systems and with each other. Experimental and theoretical investigations are then conducted as required for verification of those concepts which are promising. Studies which will be conducted include: (1) the production and storage of antimatter and the control of matter-antimatter annihilation, (2) methods of tapping energy available in space such as may be obtainable from the interaction between a fluctuating magnetic field located in the vicinity of a planet and an electrically conducting fluid in turbulent motion aboard the spacecraft, (3) system analysis of the use of indigenous materials for propulsion and power, (4) the utilization of planetary atmospheres, (5) efficient physical processes for converting a high energy density source into thrust, and (6) laser propulsion.

W76-70336 **506-21-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GENERATION AND STORAGE OF ACTIVATED SPECIES
P. J. Meeks 213-354-2506

The main objective of this task is to perform experimental and theoretical investigations of methods of producing and increasing the lifetime of excited states of helium and other atomic and molecular species in both the superfluid and solid phases of helium. A second objective is to perform experimental and theoretical investigations of producing and stabilizing solid materials containing very high concentrations of hydrogen/deuterium, and also producing and stabilizing solids which have undergone electronic collapse. A third objective is to perform theoretical investigations of metallic hydrogen, thereby complementing the experimental work being done at LeRC.

W76-70337 **506-21-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACECRAFT LIQUID PROPULSION RESEARCH
Paul J. Meeks 213-354-2546
(506-21-21)

The combustion, injection, ignition, and wall compatibility characteristics of those propellant combinations utilizing fluorinated oxidizers and amine fuels are being studied both experimentally and analytically. The objective is to provide fundamental understanding of the interacting chemical processes that are essential to the development of a technology base that forms a precursor to the application of these high performance propulsion systems to unmanned space exploration missions. Of particular interest is the formulation of an analytic representation (computer model) of a rocket combustor which predicts performance in terms of specific impulse and compatibility in terms of chamber lifetimes and integrity as well as plume effects on presumed adjacent spacecraft components and structures. In its completed configuration the input parameters for such predictions must be limited to those quantities (such as dimensions and assigned flows) that are a-priori known. The concomitant instrumentation required for the experimental work is being developed.

W76-70338 **506-21-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLID PROPELLANT RESEARCH
P. J. Meeks 213-354-2546
(506-21-32)

The objective of this RTOP is to establish scientific bases for the chemical formulation, mechanical design, and surveillance of solid propellants for rocket motors. Theoretical and experimental investigations will be performed in rheology, network structure, ingredient synthesis and purification, and curing and degradation chemistry to: (1) obtain a better understanding of propellant mechanical property, processing and environmental stability characteristics to permit the formulation of techniques for the control thereof; and (2) derive information which will enable one to design motors as structurally integrated units with a minimum of empirical study and to predict their useful lifetimes on the basis of expected environmental patterns.

W76-70339 **506-21-53**
Lewis Research Center, Cleveland, Ohio.
CHEMICAL PROPULSION RESEARCH
D. A. Petrash 216-433-4000

The objectives of this work are to expand the basic understanding of injection, mixing, combustion, and other chemical physical processes in chemical propulsion systems in order to provide higher performing, more reliable, and lower cost systems for future missions. These objectives will be attained through theoretical studies to delineate the important design parameters required to achieve engineering improvements, experimental studies to demonstrate the validity of specific theoretical approaches and design parameters, and exploratory studies to investigate new techniques or theoretical approaches that will provide further engineering improvements in liquid rocket engines. Areas in which this effort will be applied are the following: (1) combustion, (2) fluid flow, and (3) thermodynamic, transport and kinetic data.

W76-70340 **506-21-54**
Lewis Research Center, Cleveland, Ohio.
SPACE SAFETY RESEARCH
P. M. Ordin 216-433-4000

The objectives are to obtain a better understanding of the hazards and improve the safety of NASA and contractor operations associated with oxidizer and fuel systems and related propellants for flight, R&D facilities and ground service equipment. Specific areas of current interest include: preparation of criteria for the design and operation of propellant systems, investigations of the initiation of oxygen system failures induced by contaminants, investigations of combustion and nonideal explosions caused by propellant spills and tank ruptures, and the analysis and tests of gravity effects on fire extinguishment systems.

W76-70341 **506-21-55**
Marshall Space Flight Center, Huntsville, Ala.
LAUNCH VEHICLE PROPULSION
J. A. Lombardo 205-453-3791
(502-04-21; 502-24-21)

The effort described in this RTOP is directed toward improving the boundary layer JANNAF reference program which predicts rocket thrust chamber boundary layer performance loss and heat transfer. The predicted boundary layer losses obtained from existing turbulence models will be compared with boundary layer measurements derived from hot fire tests at high area ratio now planned under an existing program. The analytical models will then be revised as indicated by the experimental data. Should the experimental data indicate that model revision is not required then an alternate study to investigate the desirability of using a kinetic rate control method in place of the present chemical equilibrium method in the boundary layer model will be conducted.

W76-70342 **506-22-10**
Goddard Space Flight Center, Greenbelt, Md.
AUXILIARY ELECTRIC PROPULSION SYSTEMS
Robert A. Callens 301-982-4205

Unmanned meteorological, communication, earth observation, and other application satellites require, not only long-lived, light-weight spacecraft propulsion systems, but also ones capable of providing north-south station keeping, procession control, east-west station keeping, or precise attitude control. The objective of this RTOP is to identify and develop electric propulsion

systems that promise to provide substantial improvement over conventional propulsion systems. When necessary, they are evaluated at GSFC's facilities and space flight tests of candidate systems are conducted to further demonstrate their capability for space flight application.

W76-70343 **506-22-11**
Lewis Research Center, Cleveland, Ohio.
AUXILIARY PROPULSION ION THRUSTER TECHNOLOGY
R. C. Finke 216-433-4000

The objectives are (1) to develop prototypical one-millipound mercury ion thruster system hardware and subject it to flight qualification level testing, and (2) to provide the technology to extrapolate mercury ion thruster performance at larger or smaller thrust levels. The technology developed will result in hardware for flight prototype thruster subsystems of demonstrated efficiency and durability, thus assuring a firm base of technology-ready hardware for application to anticipated auxiliary electric propulsion controlled spacecraft.

W76-70344 **506-22-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CHARACTERIZATION OF PULSED PLASMA THRUSTER INDUCED ENVIRONMENT
A. Briglio, Jr. 213-354-6137

The exhaust plume of both a micropound and millipound pulsed plasma thruster will be examined during operation in two vacuum facilities. These results will be used to evaluate (1) the amount of ion and neutral material impingement on various locations downstream of the thruster, and (2) the amount of degradation due to surface contamination that might be expected in the function of spacecraft solar cells, thermal control, and optical surfaces. The amount of infrared interference of the plume with infrared sensing spacecraft instrumentation will also be examined. The environment exhibited by both a LES-6 micropound-second thruster and a millipound-second thruster will be characterized. The plume of each thruster will be experimentally investigated in detail in a 9 ft. dia. vacuum tank. Instrumentation for in-situ determination of surface effects will also be developed in this facility. These results will be verified in the liquid-helium-cooled Molsink facility which provides a nearly ideal simulation of the vacuum and cold sink of space for surface effects testing. An analytical model of the plume and neutral materials will be constructed from the experimental test results.

W76-70345 **506-22-30**
Lewis Research Center, Cleveland, Ohio.
PRIME PROPULSION ION THRUSTER TECHNOLOGY
R. C. Finke 216-433-4000

The overall program goal is to identify and develop the required technology to demonstrate technology readiness status for primary propulsion subsystems for proposed missions. Development and testing of thrusters, power processors, and interface elements will be done to optimize element performance, lifetime, and reliability and also define and characterize the critical system interfaces and requirements. The program will result in a baseline technology and design criteria for application to anticipated electric propulsion spacecraft. A major program will be to define requirements, develop to engineering model status, and verify by life tests and multiple thruster operation, primary propulsion thrusters which satisfy the range of requirements of foreseeable missions. Power processors will be designed and developed to functional model status, integrated with thrusters, and verified by system level and lifetime testing. Other critical system elements such as gimbals, propellant storage and distribution system, and thrust subsystem-spacecraft interface hardware and software will be simulated and integrated into a functional subsystem. Thrust subsystem interactions and integration problems will be investigated to the extent necessary to clearly define critical interfaces and system requirements and reduce risk in future applications.

W76-70346 **506-22-32**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION AND PAYLOAD APPLICATIONS
L. E. Young 205-453-2110
(180-17-57)

The objective of this RTOP is to insure the availability of solar array technology which meets solar electric propulsion requirements. The approach is to perform a preliminary design in order to identify the solar array technology required to support solar electric propulsion. This technology will be compared with the state-of-the-art to identify areas where demonstration of further development of technology is needed. These areas will be worked as specific tasks with results being fed back into the design effort. The availability of overall array technology will be demonstrated by fabricating and testing a full-scale wing. To accomplish the objective, the following tasks will be performed: (Task 1 was completed in Dec. 1974), (1) preliminary design for identification of required technology, (2) materials demonstration, (3) thermo-compression bonding of solar cells to electrical interconnects, (4) solar cell selection and characterization, (5) solar cell module thermal cycling, (6) nondestructive inspection and tests, and (7) full-scale wing technology demonstration.

W76-70347 **506-22-33**
Marshall Space Flight Center, Huntsville, Ala.
SEPS ENVIRONMENTAL IMPACT
J. B. Stephens 205-453-2114
(180-17-56)

This RTOP is for the investigation of the parametric qualities associated with terrestrial perturbations in the lower stratosphere and the troposphere from the release of mercury. The study contract for RTOP 180-17-57 on the Environment Impact of Solar Electric Propulsion revealed that a detailed analysis of the effects of a mercury release from a failure mode in these regions of the atmosphere required additional definite investigation to establish reaction rates and diffusion parameters. This work will address two separate problems: (1) the reactions and rates of mercury with ozone to determine the long term effects of mercury on the ozone layer in the lower stratosphere; and (2) the development of mathematical methods to account for the deposition and diffusion of mercury in the troposphere.

W76-70348 **506-22-40**
Lewis Research Center, Cleveland, Ohio.
ION THRUSTER RESEARCH
R. C. Finke 216-433-4000

The objective of this work is to increase the knowledge of electron-bombardment ion thrusters in an orderly and meaningful manner. Basic physical processes are studied, both experimentally and analytically, for a range of thruster sizes commensurate with thrust levels of 2 to 500 millinewtons. Although mercury vapor is the chief propellant used, other propellant gases, such as argon and xenon are also studied for specific mission or ground-based applications. A further objective of this work is to define and understand interactions between ion thrusters and the spacecraft, mission and science payload. Experimental and analytical studies are conducted through grants, contracts and in-house programs. Specific programs include: (1) probing the plasma discharges of the thruster to identify reactions and support analytical theory, (2) developing analytical theory to predict thruster limitations and ultimate performance, (3) novel ways to improve thruster starting reliability, such as the use of a HV pulse to light the cathodes, (4) measurement and control of thruster efflux, both in the thruster and on spacecraft surfaces, and (5) the measurement of electromagnetic and magnetostatic fields produced by the thruster system and their effect on the spacecraft/science payload.

W76-70349 **506-22-41**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PLASMADYNAMIC LASER RESEARCH
George R. Seikel 216-433-4000

The objective is to define the feasibility and potential of novel plasma laser concepts that exploit technology developed for electric propulsion. Investigations are aimed at understanding the controlling physical processes to determine limitations on efficiency, power density, and attainable laser wavelength regions. Investigations will aim to define and meet laser requirements for potential high-power applications of interest to NASA. Analytical and experimental studies which include extensive

diagnostics will be made. Novel concepts such as charge-exchange ion lasers will be explored and attempts to demonstrate their feasibility in MW quasi-steady experiments will be made. Research will include estimating performance of laser concepts and use of lasers. High power lasers are potentially of interest to NASA for a number of applications. However, at present only molecular long output wavelength lasers (e.g., CO2 laser output is 10.6 microns) can operate at high (greater than kw) average output power. This research will explore the feasibility of developing high power ultraviolet and/or visible wavelength ion and atom lasers using novel high power flowing plasma technology concepts.

W76-70350 **506-22-43**
Lewis Research Center, Cleveland, Ohio.
ION BEAM APPLICATIONS RESEARCH
R. C. Finke 216-433-4000

The broad objective of the work described is to provide the basic research and technology needed to define and develop nonpropulsion applications of electrostatic accelerator technology. By conducting pertinent experimental and analytical studies, the overall program is directed at demonstrating fruitful application of the unique capabilities of electrostatic accelerator technology to the improvement of the state-of-the art of (1) sputter deposition by ion beam, (2) ion sources for fusion systems, (3) ion milling and polishing, and (4) space manufacturing applications. Major programs are directed at identifying applications which could strongly benefit from the unique capabilities inherent in this technology. Specifically, the program goals are to identify manufacturing processes which could substantially benefit from the ability to clean and etch a substrate and deposit layers of virtually any material in a high vacuum environment, free from undesirable contaminants. Freedom to independently control substrate temperature may allow the material to be deposited in structure ranging from epitaxial to amorphous. Controlled impurity deposits and graded layers will be investigated. Large, high current, well-neutralized ion beams for injection into magnetic bottles will be investigated. Other applications requiring the unique capabilities of this technology will be explored and investigated.

W76-70351 **506-22-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PULSED MPD ARC JET WITH INDUCTIVE ENERGY STORAGE
A. Briglio, Jr. 213-354-6137
(506-24-31)

The objective of this RTOP is to investigate and assess the feasibility of operating quasi-steady MPD arc jet thrusters directly from a nuclear thermionic power source through an inductive storage device. The magnetoplasmadynamic (MPD) arc jet is an electro-magnetic plasma thruster which operates from a low voltage (100-150V) at high current (greater than 10,000 A). The self-inductance of this device at large current levels generates a desired magnetic field for propellant acceleration, increasing the propulsion efficiency. The thruster operates at lower average power by pulsing, where very large capacitors are presently used for energy storage. It now appears that inductive energy storage could lead to a more desirable power system development than capacitive storage. The feasibility of this concept requires study.

W76-70352 **506-23-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY SOLAR POWER RESEARCH AND TECHNOLOGY
A. Briglio, Jr. 213-354-6137

A listing of the JPL FY-76 program for planetary solar arrays and solar cell technology development is given below: (1) continue the program to develop lightweight solar arrays, (2) continue the development of .01-cm-thick high-efficiency solar cell, (3) continue the development of low-cost solar array technology, (4) continue the program to test and evaluate solar cells for deep space applications, (5) development of improved radiation-resistant cells, (6) continue the silicon research program, and (7) continue the inversion layer solar cell program. This work will be accomplished through combined in-house and contracted efforts with industry and universities.

W76-70353 **506-23-15**
Goddard Space Flight Center, Greenbelt, Md.
HIGH EFFICIENCY SOLAR CELL DEVELOPMENT AND EVALUATION
L. W. Slifer 301-982-4841

The objective is the development of high efficiency solar cells into production line item, and the evaluation of production line cells for space flight use. The approach is to (1) evaluate pilot line samples of high efficiency cells, (2) transfer technology to production line, (3) evaluate production progress samples, (4) flight qualify production cells, (5) develop large area production cells, (6) develop thin production cells, (7) perform yield and cost analysis, (8) develop detailed production procedures, (9) develop quality assurance requirements, and (10) develop high efficiency solar cell specification.

W76-70354 **506-23-17**
Lewis Research Center, Cleveland, Ohio.
SOLAR CELL TECHNOLOGY
D. T. Bernatowicz 216-433-4000

The objective of this RTOP is to develop the technology for low-cost solar cells and arrays with high end-of-life efficiency. Research and technology programs will be continued in the following areas: (1) research into the basic loss mechanisms in photovoltaic devices; (2) development of cells with improved end-of-life efficiency, including epijunction cells, back surface field cells, heavily doped cells, and cells with wraparound contacts; (3) investigation of processes for fabricating low cost cells, including continuous growth of web-dendrite ribbon, automation of wafer cell fabrication, thick film processes for contacts and interconnects, and low cost reduction and purification of silicon; (4) development of FEP-covered solar cell modules, and (5) flight experiments to evaluate improved solar cells and modules.

W76-70355 **506-23-22**
Goddard Space Flight Center, Greenbelt, Md.
BATTERY QUALITY CONTROL AND TESTS
T. J. Hennigan 301-982-5547

The objectives are to: (1) advance battery material development, (2) investigate areas that will lead to an increase in the usable energy density of nickel cadmium cells, (3) improve cell and cell component characterization methods for application to fabrication process control, (4) develop analytical methods for cell component analysis, and (5) maintain a NASA Test Facility to perform battery life tests and investigate methods of accelerated cell/battery testing.

W76-70356 **506-23-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE
A. Briglio, Jr. 213-354-6137
(506-23-33)

This RTOP is directed toward providing the battery technology to support future planetary missions and terrestrial applications. The objectives, in accord with the NASA Program Objectives, are to attain long-life (10-year), high-energy-density, and highly reliable and low-cost electrochemical energy storage devices by advancing the technology of its components, operating and storage techniques, and test and evaluation procedures. Specific targets are: (1) to advance the state-of-art of the nickel-cadmium technology by developing a cell capable of a 10-year life and an energy density of 25 Wh/lb., and by establishing a nickel-cadmium predictive model based on all available empirical data, and by reducing costs through innovative designs and operational techniques such as with non-gassing cells; (2) to develop primary batteries for planetary probe missions that can deliver high power outputs (15C) after prolonged (7-10 years) storage; (3) to develop advanced battery electronics including modular sequential charging and pulse charging thereby improving reliability and extending the lives of cells and batteries; and (4) to determine the effects of a zero-gravity environment on high power outputs of nickel-cadmium, silver-zinc and nickel-hydrogen batteries through the use of test vehicles such as the Astrobee Sounding Rocket and the shuttle.

W76-70357 **506-23-24**
Lewis Research Center, Cleveland, Ohio.
ELECTROCHEMICAL DEVICES
Harvey J. Schwartz 216-433-4000

The object of this program is to attain long-life, high energy densities and high reliability for electrochemical energy storage devices. In order to meet this objective, work will be performed to develop silver-zinc batteries with 4-5 times the energy density of nickel-cadmium batteries for 5 years life in synchronous orbit and planetary applications by FY 1978. A longer lived (10 year) higher energy silver-hydrogen synchronous orbit battery will be developed by FY 1979. A high energy sodium-sulfur cell using a glass fiber electrolyte will be demonstrated by FY 1978. Solid electrolytes suitable for operation in alkali metal batteries of the 100-150 WH/lb class will be identified by FY 1976. Testing of a prototype cell for a 20 lb/KW, 10,000 hour life H2-O2 fuel cell system will be completed by FY 1977.

W76-70358 **506-23-30**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LOW COST POWER PROCESSING AND DISTRIBUTION TECHNOLOGY
P. A. Thollot 216-433-4000
(506-23-31)

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve aerospace power processing and distribution systems. Terrestrial applications will also be considered in the establishment of this technology. Addressed are, improvements in electrical circuit performance, and the general optimization of power processing and distribution systems including development of advanced circuit techniques and the utilization of integral solar array power regulation and conditioning. In addition to general technology, this program has, as an objective, directed technology for specific applications. Included in this category are: (1) power processing concepts with efficiencies in excess of 90% and power densities with a target value of 2.5 kg/kW for ion thrusters and other high voltage loads, and (2) modular power conditioning techniques leading to low cost, reusable space applications and shuttle requirements. Also included in this program is an effort directed toward developing engineering tools, using modeling and analysis techniques, which will enable designers to rapidly and accurately assess total system interaction and trade-off effects, e.g. weight vs. efficiency, cost vs. efficiency, etc. Contract and in-house studies will be implemented to perform analytical and experimental investigations and hardware fabrication as required to establish the technology of new circuits and power processing and distribution systems.

W76-70359 **506-23-31**
Lewis Research Center, Cleveland, Ohio.
HIGH PERFORMANCE POWER ELECTRONICS COMPONENTS
P. A. Thollot 216-433-4000
(506-23-30)

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve electronic power components and subsystems and to investigate interactions between the electrical systems and the environment of spacecraft. This includes the development of improved electronic power components as required for use in low weight, high efficiency power processors and distribution systems. It also includes the effects of photoconductivity in space type electrical insulating materials at high voltages. Contract and in-house studies, experimental investigations, and hardware fabrication will be performed as required.

W76-70360 **506-23-32**
Goddard Space Flight Center, Greenbelt, Md.
POWER PROCESSING FOR EARTH ORBITAL SPACE SCIENCE AND APPLICATION SATELLITES
Edward R. Pasciutti 301-982-4885

This RTOP defines a program in power electronics utilizing university and industry personnel and facilities. GSFC personnel involvement is limited to the extent of initiation, guidance, and evaluation plus, as warranted, a necessary amount of exploratory investigation, or advanced in-house design and development. The RTOP objectives are: to expand the power electronics technology base, to lower cost by both reducing development time and the achievement of commonality of designs, to use new components, circuits, and increased frequency bandwidths to reduce size and weight, to improve high voltage, circuit reliability through research of circuits, components, materials, potting and assembly techniques.

W76-70361 **506-23-33**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LONG-LIFE, HIGH-PERFORMANCE POWER PROCESSING FOR PLANETARY APPLICATIONS
A. Briglio, Jr. 213-354-6137
(506-23-23)

The objective of this RTOP is to develop and demonstrate advanced power processing and distribution and related system configuration and integration technology to meet the requirements of future planetary spacecraft. These requirements, as identified in NASA's Objectives Documentation, include longer life, higher performance, higher reliability and lighter weight than is achieved with existing technology. The intent of this work is to develop designs that not only can meet the technical requirements but which can also be built and incorporated into the spacecraft power system for minimum cost. In developing the necessary capability, techniques and hardware it is required that the specialized requirements of both solar and sun-independent power sources be accommodated. The basic approach being taken is to develop modular designs for the major power processing elements within the spacecraft power system. These designs are standardized to the maximum extent possible and feature active rather than standby redundancy. This minimizes the total number of separate modules required in the system and, hence, the cost to build and test it. High-performance circuits are used throughout, and the basic approach offers a large degree of flexibility for scaling the system to different input voltages and power levels, thus providing capability for multiple applications. Additionally, standardized design and analysis methods are being developed and applied for all power processing circuits used in planetary spacecraft power systems, and test methodology and equipment for multi-redundant power systems are being developed.

W76-70362 **506-23-34**
Marshall Space Flight Center, Huntsville, Ala.
MULTI-KW DC DISTRIBUTION SYSTEM TECHNOLOGY
J. L. Felch 205-453-4634

As part of the NASA space vehicle technology development program, the Marshall Space Flight Center conducted a comprehensive Space Vehicle Electrical Power Processing, Distribution and Control study. This study, which was completed in late 1972, disclosed that significant reductions in weight, greater design flexibility, reliability, and lower cost can be realized for large future aerospace vehicles through use of higher dc distribution and transmission voltage (above 100 Vdc) when compared to conventional 28 Vdc or 115 Vac systems. It also showed that maximum benefit can be obtained when high voltage dc distribution is coupled with use of remotely controlled solid state switchgear and multiplexed computer controlled supervision and checkout of the electrical system. The approach which has been selected for providing technology-readiness consists of test and demonstration of complete multi-kw power distribution systems using voltages up to 300 Vdc. The following task will be performed: design, fabrication and operation of a flexible technology breadboard test facility to be installed at MSFC.

W76-70363 **506-23-35**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AUTOMATED POWER SYSTEMS MANAGEMENT
A. Briglio, Jr. 213-354-6137

Future planetary spacecraft will have to perform for greater periods of time, more remotely from ground control, in more hostile environments than their predecessors. Furthermore, missions will become more complex involving orbit changing and real time adaptive sequence changes for planetary orbiters and rovers. It is the more demanding aspects of future missions

which establish unique requirements upon power system capability, reliability, and operation. System capability will be pressed by the wide variations in power system parameters which are dependent upon distance and mission duration. Reliability requirements will be determined by the need to perform for up to 10 years. Operations will be significantly impacted by the increased action/reaction cycle time (up to 8 hours). Perhaps the most stringent demands will be for the power system to accommodate real time changes in mission execution and to provide fault correction capability autonomously, because intervention from ground stations cannot occur in real time. The work described in this RTOP will develop the technology required to achieve autonomous capability in planetary spacecraft power systems. Referred to as APSM, Automated Power Systems Management is the capability of a spacecraft power system to automatically perform monitoring, computational, command, and control functions without the need for ground intervention. The effort will include analysis, design, development, and evaluation of hardware and software necessary to demonstrate the readiness of APSM technology in FY-80. APSM technology will be developed for Mariner class solar array and RTG powered systems, and battery powered (entry probe) systems. Major technical emphasis will be with respect to defining the appropriate functions to be managed, sensor development, interface definition, software algorithms, and breadboard demonstrations using off-the-shelf computer hardware.

W76-70364 **506-23-40**
Lewis Research Center, Cleveland, Ohio.
THERMO-MECHANICAL ENERGY CONVERSION
R. P. Migra 216-433-4000

The objective of this RTOP is to provide a technology base for high-efficiency, long-life, low-cost, thermo-mechanical space power conversion systems applicable to near-term NASA missions, (early 80's). This program will include a demonstration of the Brayton power conversion process in the fractional-to-2 kilowatt power level. NASA missions in the early 80's appear to require power levels in the neighborhood of 1 kilowatt. Several of these missions, especially deep space probes, cannot use solar arrays. In addition, certain DOD missions in this time period require compact power systems with long life and in the range of 1 kilowatt power output. To fulfill these needs and especially to provide confidence for mission selection, a proof-of-concept Brayton demonstration system will be designed, built, and run to demonstrate failure-free and unattended operation for a continuous period of at least two years. The 10 KW sub e engine under endurance testing at LeRC will receive a total teardown and inspection at 20,000 hours and be reassembled for continued endurance testing to 50,000 hours if warranted by inspection.

W76-70365 **506-24-11**
National Aeronautics and Space Administration, Washington, D.C.
PLASMA CORE REACTOR RESEARCH
K. Thom 202-755-3066
(506-25-31)

The objective is to establish the scientific understanding of gaseous 235 UF6 nuclear reactors and plasma core nuclear reactors for the future development of such energy sources for major advances in space propulsion and in the generation and conversion of nuclear energy in space and on earth. Specifically, to elaborate the physics of cavity reactors that are fueled with a gaseous fissioning medium at stationary conditions and under condition at which the fuel is flowing through the reactor and is confined by a wall jet inflow of buffer gas. In addition, to investigate the non-equilibrium distribution of ionized and excited states in the fissioning gas and possibility of nonequilibrium e.m. radiation. The HQ funded research at the Los Alamos Scientific Laboratory (LASL) includes (1) nuclear pumped laser research for direct conversion of fission fragment energy into coherent e.m. radiation, using the LASL GODIVA fast burst reactor, (2) gaseous fueled cavity reactor theory and experiments to establish the reactor physics of such systems, to prove their safety and control, and to probe their usefulness in respect to goals, employing a beryllium moderator-reflector, a control system, and a pressure vessel salvaged from the previous NASA Nuclear Rocket Program, and (3) LASL will subcontract United Aircraft Research Laboratory for UF6 handling research and to design and fabricate UF6 canisters and flow systems components for insertion into the reactor cavity.

W76-70366 **506-24-11**
Langley Research Center, Langley Station, Va.
PLASMA CORE REACTOR RESEARCH
E. S. Love 804-827-2893
(506-25-31)

The objective is to establish the scientific understanding of 235UF6 and 235U plasma-core nuclear reactors and to study their technological usefulness. Emphasis in this basic research is on the physics of fission fragments - gas interactions to understand the mechanisms of nuclear-induced electromagnetic radiation, the transport of this radiation and its conversion to useful forms of energy. In addition, a major effort of research is directed toward fluid mechanical confinement of fissioning gaseous nuclear fuel and for flow and materials studies of UF6 and uranium vapor handling systems. The fluid mechanics, UF6 handling and part of the optical radiation research will be conducted under contract under LaRC direction. Other supplementary radiation research is conducted under the LaRC 506-25-31 RTOP. Nuclear reactor experiments will be conducted under a separate NASA Headquarters RTOP.

W76-70367 **506-24-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NUCLEAR PUMPED LASERS
T. Vrebalovich 213-354-4530

The primary objective of this work is to develop high pressure, visible and vacuum ultraviolet lasers where the laser pumping is provided by a pulsed nuclear reactor. A secondary objective is to conduct supporting theoretical and experimental research which will lead to an understanding of the kinetic processes responsible for lasing in high pressure plasmas produced by the products of nuclear reactions.

W76-70368 **506-24-16**
Lewis Research Center, Cleveland, Ohio.
BASIC STUDIES IN HEAT TRANSFER AND FLUID MECHANICS
Lester D. Nichols 216-433-6203

The objective is to provide basic knowledge required to predict and control processes involving hot gases, reacting constituents, coolants, and radiant heat fluxes as they occur in energy-transfer systems. The work involves efforts in the research areas of heat transfer and fluid mechanics. The approach is to study basic behavior and processes applicable to whole classes of energy-transfer systems. Theoretical models of processes are developed and are tested by comparison with experiment. These experiments are generally small scale, and are devised to produce general information needed for predicting performance of full-scale systems. The ideal performance of an energy-transfer system is an essential benchmark in assessing the performance of such a system. It is often the rationale for assigning an efficiency or coefficient of performance.

W76-70369 **506-24-21**
Lewis Research Center, Cleveland, Ohio.
HIGH-EFFICIENCY THERMIONIC CONVERSION
James F. Morris 216-433-4000

The objective is to acquire the technology required for high-efficiency thermionic conversion of heat from various energy sources for use in a wide range of power-generation applications. Coordinated contract, grant, and in-house theoretic and experimental studies will yield better emitters, collectors, and ion generators. The resulting reduced electrode work functions and interelectrode losses will produce more efficient thermionic converters, which will in turn lead to more effective space power systems. Justification of this thermionic-conversion work appears on page 12-2.1 in the PASO document and in the following paragraph. To meet all eventual NASA needs, thermionic R&T must provide for low to near-megawatt power levels, and high space power requires high waste-heat-rejection temperatures to obtain

acceptable radiator weights. So the NASA program must cover the full range of thermionic-conversion temperatures.

W76-70370 **506-24-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW-TEMPERATURE THERMIONIC CONVERTER
T. Vrebalovich 213-354-4530
(506-24-31)

The long range objective is to develop a low-temperature converter having a conversion efficiency which is more than twice that of high-temperature converters. In the high-temperature converters, reradiation heat losses from the high-temperature emitter are a significant part of the total input energy required to operate the converter. This reradiation loss can be drastically reduced by lowering the emitter temperature. Resulting reduction of thermionic emission current can be readily compensated by a reduction of emitter work functions (from 3.0 eV to 2.0 eV). However, the smaller emitter work function creates a need for a collector work function as low as 1.0 eV so as not to lose the output voltage. Thus a development of a low work function collector, which operates at a temperature as high as 800 K, becomes necessary. The immediate objective is to fabricate and test a low temperature converter having an appropriate emitter such as a barium oxide cathode and a low work function collector. The first collector tested will be a negative electron affinity (NEA) type electrode and the second choice will be a metal-oxygen-cesium electrode system. For reducing the plasma losses, effects of molecular nitrogen on the converter output voltages, and a discrete ion source approach will also be investigated.

W76-70371 **506-24-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THERMIONIC SYSTEMS TECHNOLOGY
T. Vrebalovich 213-354-4530
(506-24-22)

The long-term objective of this technology effort is to achieve high efficiency nuclear thermionic power subsystem technology readiness for application to space power. The intermediate objective is to establish the feasibility of key technology items, and evaluate the capability for low-cost production of thermionic systems. These objectives are accomplished through system design studies and a well-defined directed technology effort at the component and subsystem levels. Work is to be coordinated with applicable technology efforts from other programs. A typical thermionic power subsystem consists of a heat source, thermionic converters, heat exchanger, heat rejection radiator, pumps, controls, structure, nuclear shielding, power processing, and distribution. The power subsystem is expected to be integrated with electric propulsion in a nuclear electric propulsion (NEP) stage for exploration of the outer planets in the 1990's. Other applications, both for space power and terrestrial power, will be studied as appropriate. In particular, low-cost solar concentrators with low-cost, high-efficiency thermionic converter technology are to be evaluated in the FY 75-76 program.

W76-70372 **506-25-11**
Lewis Research Center, Cleveland, Ohio.
PLASMA DYNAMIC ENERGY SYSTEMS
George R. Seikel 216-433-4000

The objective is to establish the knowledge required to produce, confine, and utilize plasmas for advanced power and propulsion systems of potential importance to NASA, and to understand the fundamental physical processes involved in plasmadynamic energy systems. Analytical and experimental studies which include extensive diagnostics will be made. Topics to be investigated include: MHD generators for both open and closed cycle electric power systems, and high-temperature (fusion) plasma heating and containment in open and closed magnetic geometries. Investigations will include studies to define potential system performance, critical technology needs, system concepts leading to new NASA capabilities and missions, and alternative applications of technology developed. Justification: An improved understanding of the physics and of the dynamics of plasma is needed to acquire the ability to generate and manipulate plasmas in ways serving specific objectives related to NASA programs. Among such potential applications of objectives are space propulsion and power generation (embracing not only MHD generators, but also controlled thermonuclear reactors). The objective, targets, need, and relevancy of this research are described on pages 13-1.0 to 1.1 of the PASO document.

W76-70373 **506-25-21**
Lewis Research Center, Cleveland, Ohio.
MAGNETICS AND CRYOPHYSICS
Gerald V. Brown 216-433-4000

The objective is to achieve intense magnetic fields in large volume with minimum mass and power requirement; to conduct research on superconducting materials to improve stability, current density, operating temperature, and strength; and to study the low temperature and/or intense field characteristics of materials and devices of significance to refrigeration, power, and propulsion applications. Basic and applied research in magnetic cooling and solid state physics are included. A new mechanical design and forced-convection LNe heat transfer will be applied in a cryogenic magnet to produce a 30 T steady-state magnetic field. (Present record steady field is 22.6 T). High-field superconductors (e.g. Nb2Sn) will be produced in a substantially improved composite form to give magnetically stable, high current density magnet windings. The potential high efficiency of magnetic heat pumps and refrigerators will be evaluated by building and testing devices in the entire range from 4 K to room temperature.

W76-70374 **506-25-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
FUNDAMENTAL PHOTONICS
T. Vrebalovich 213-354-4238

The objective of the laser kinetics task is to conduct the research required to develop various types of high power, efficient, short wavelength lasers. Emphasis is placed on understanding the basic physical phenomena that determine the efficiency, wavelength, size, and power output of laser devices. The principal objective of the electron impact spectroscopy task is the generation of reliable cross sections for electron-molecule (atom) interactions. Particular emphasis is placed on obtaining cross sections for use in the understanding of the behavior of high energy lasers, plasma devices, and the energy degradation of high energy electrons. The objectives of the nuclear Zeeman maser task are: (1) to study the feasibility of constructing a nuclear Zeeman maser, (2) to investigate the characteristics of such a maser as an oscillator and as a low temperature rf amplifier, and (3) to develop and apply the NMR line narrowing technique to Mossbauer systems in order to enchance the resonant emission or absorption cross section of gamma rays, which might eventually lead to the gamma ray laser system. Theoretical and experimental development of distributed feedback (DFB) as a laser optical system will be applied to various lasers that currently exhibit external mirror problems. A theory for self-sustained DFB will be developed. An attempt to induce laser action in He 2 (800 A) will be made. In the physics of molecular interaction program, basic research on the chemical and physical interactions of ions, electrons, metastables, and molecules is conducted, with particular emphasis on processes involving the production of excited states. A related applied research study is underway to develop a new class of charge transfer ion lasers.

W76-70375 **506-25-31**
Lewis Research Center, Cleveland, Ohio.
FUNDAMENTAL PHOTONICS
J. W. Blue 216-433-4000

The LeRC cyclotron accelerates all the isotopes of hydrogen and helium to energies as high as 75 MeV. These high energy particles are used to excite atoms and/or nuclei for the following purposes: to cause: (1) nuclear excitations for possible use in a gamma ray laser (graser), (2) radiation effects on optical windows used to view the plasma in fusion and fission devices, and (3) atomic excitation of inner electron shells created for trace emelent analysis of environmental samples. The approach is (1) to study photonic recoilless emission from nuclei and thereby to determine the energy, level width and lifetime of nuclear states, (2) high energy protons are used to simulate fast neutrons and gamma radiation and the optical opacity determined as a function of

temperature and dose rate, and (3) opacity measurements of glass microspheres containing H2, D2 and He3 at 100 atm. made during and after proton bombardment.

W76-70376 **506-25-31**
Langley Research Center, Langley Station, Va.
FUNDAMENTAL PHOTONICS
E. S. Love 804-827-2893

The fundamental characteristics of a fissioning uranium plasma will be investigated to determine the feasibility of direct conversion of nuclear energy into electromagnetic radiation, laser power or work. The thermodynamic properties of uranium hexafluoride will be investigated and the interaction of fission fragments with uranium hexafluoride and other gases will be determined. Radiation induced plasmas will be studied to determine possible population inversion, nonequilibrium emission, and ionization and excitation cross sections. A new hypocycloidal plasma focus will be constructed with greatly increased plasma confinement time. The increased neutron production expected from this device should improve the production of fissioning uranium plasmas by increasing fission yield. The interaction of intense CO2 laser radiation with the dense plasma focus will be investigated, specifically the efficient conversion of laser radiation to X-rays. Photo catalysts will be investigated with the aim of providing direct photo-dissociation of water by sunlight. A new hypocycloidal plasma focus will be constructed and tested for possible use in the production of a fissioning uranium plasma. Studies on the properties of fissioning uranium plasma produced in the LRC plasma focus device will continue. Research on fission-fragment induced plasmas, on characteristics of the radiation emitted from fissioning plasmas, and on photo-electrochemical production hydrogen will be performed under grants to various universities.

W76-70377 **506-25-31**
National Aeronautics and Space Administration, Washington, D.C.
FUNDAMENTAL PHOTONICS
K. Thom 202-755-3066

The objectives are to do fundamental physics research on e.m. radiation-matter interactions, to explore the principles of the generation, conversion, and utilization of power at energy levels much higher than used in conventional thermodynamic systems, for greatly improved capabilities in space propulsion and the usage of energy in space and on Earth. In particular, the objective is to explore means of power generation from fission fragment-gas interactions in form of e.m. radiation in the visible to ultraviolet spectrum, to generate laser power directly in this spectral range, and to investigate basic principles of the direct conversion of laser power into electricity, or mechanical work without going through phases of thermalization of energy. The approach is through the following grants: University of Florida research on nuclear pumped lasers and fissioning plasma radiation. University of Washington for research on direct laser power conversion, and laser plasma heating. Stanford University for research on laser-electron beam interactions.

W76-70378 **506-25-32**
Ames Research Center, Moffett Field, Calif.
QUANTUM ELECTRONICS
D. R. Chapman 415-965-5065
(506-25-61)

The objectives are to conduct experiments and analysis of topics in the physics of quantum electronics that provide basic data on, and understanding of, the interaction of laser radiation with matter in support of a broad range of NASA applications in propulsion, power transmission, lasers and space, and atmospheric physics. The specific approach will include an investigation of the following areas: the interaction of high intensity radiation with solids, liquids, gases, and plasmas leading to nonlinear and novel effects. Experiments will be performed to obtain inversion on ultraviolet, soft X-ray, and even X-ray transitions. Using tunable sources, investigations of excited state quenching, transfer, and chemical rate dependence will be examined. Similarly, tunable lasers will aid in investigations of isotope and isomer separation as well as laser-induced chemistry. A theoretical investigation of vibrational energy transfer in laser gases will be concluded, as will the experimental investigation of the ion-electron recombination laser. Finally, a study will be continued to determine work functions, thermal stability and atomic structure of electropositive layers co-adsorbed with oxygen on single crystal surfaces.

W76-70379 **506-25-41**
National Aeronautics and Space Administration, Washington, D.C.
HIGH POWER LASER SYSTEMS TECHNOLOGY
J. G. Lundholm 202-755-2488

The objective of this program is to evaluate the potential of high power lasers systems for NASA applications. The program will define and evaluate both space and ground-based systems for potential NASA, commercial, and/or military applications. A broad technology base is involved and must be considered for a realistic appraisal of systems and applications and for future design, development, and use of such systems. An in-depth investigation by an appropriate organization to assist NASA in defining program guidelines for the next 3 to 5 year period is contemplated.

W76-70380 **506-25-41**
Lewis Research Center, Cleveland, Ohio.
HIGH-POWER LASER SYSTEMS TECHNOLOGY
D. L. Nored 216-433-4000

The objective of this program is to evaluate by 1980 the potential of high-power lasers for NASA applications. This program will define and investigate high-power laser systems and their potential use. Both space and ground-based systems for potential NASA, commercial, and/or military applications will be included. A broad technology base will be provided, as necessary, for realistic appraisal of systems and applications, and for future design, development, and use of such systems. Efforts will concentrate on evaluation and technology investigation of flowing gas laser devices suitable for future high-power laser transmitter systems, efficient power generation systems for such devices, conversion systems for high-power laser energy receivers, optical components unique to large high-power lasers, and on screening and definition of applications. The program approach includes: (1) identification of potential applications, and in-depth evaluation of their requirements (a continuing effort); (2) component performance and system studies; (3) experimental investigation of component and subsystem technology within critical areas; (4) design and operation of high-power lasers to assist in the component technology investigation program; (5) design, fabrication and testing of high-power laser transmitter systems for evaluation of system-type problems; and (6) design, fabrication, and operation of systems and experiments applicable to potential applications, including laser propulsion.

W76-70381 **506-25-41**
Ames Research Center, Moffett Field, Calif.
HIGH-POWER LASERS
D. R. Chapman 415-965-5065
(506-25-32)

The objectives are to conduct experiments and analysis of topics in the physics of quantum electronics that relate to the development of lasers and ancillary devices suitable for NASA missions and applications solar physics, space physics, atmospheric physics, and space flight technology. This work should provide the necessary research and technology base needed to evaluate the potential of the laser for these needs. The specific approach will include an investigation of the following areas: Firstly, the development of an efficient, supersonically cooled, electric discharge carbon monoxide (COEDS) laser will be pursued. Secondly, an arc-heated GDL facility will serve as a versatile test bed to examine CW lasing at higher pressures and temperatures than previously attainable by others. Various lasant mixtures, the effect of contaminants, and supersonic injection of the lasant will also be examined. Thirdly, the study and assessment of potential laser energy converters will be pursued. After detailed examination of the pertinent physics and engineering of such candidate devices, such as metal-barrier-metal optical diodes, laser heated thermionic converters, laser engines, and laser assisted dissociators, specific devices will be experimentally

examined for conversion efficiency and suitability for space usage. Finally, the theoretical analysis and development of computer codes suitable for optimization of existing, and development of new, laser systems will be pursued. Typical of such efforts are the computer code for predicting the output power of a CO2 gasdynamic laser, and a comprehensive theory of vibrational energy transfer in anharmonic diatomic gases.

W76-70382 **506-25-41**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HIGH ENERGY LASER TECHNOLOGY
T. Vrebalovich 213-354-4530
(506-25-62)

The objective is to develop the necessary technology required to construct various types of high power, efficient, short wavelength lasers. Emphasis is placed on the development of scaling laws that govern the efficiency, size, and power output of specific laser devices.

W76-70383 **506-25-42**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LASER ENERGY CONVERSION RESEARCH
T. Vrebalovich 213-354-4530

The objective is to demonstrate the feasibility of efficiently converting laser energy to electrical energy and to advance our understanding of physics involved in the conversion process. Investigations will be made with: (1) Schottky barrier (SB) photovoltaic converter, (2) SB laser rectifier, and (3) a plasma device such as a laser phasmadynamic (LPD) converters. (1) Laser Photovoltaic (LPV) Converter: The materials to be used will be gallium arsenide and ternary III-V compounds for the visible range, and gallium phosphide, zinc selenide, and zinc oxide for the ultraviolet range. The barrier fabrication will be the Schottky barrier technique, (thin metal film-semiconductor). Emphasis will also be placed on control of the interfacial layers on the semiconductor. These layers can significantly increase voltage outputs, and hence, conversion efficiency. Multilayer barrier devices will also be tested. (2) Laser Rectifier: The feasibility of rectifying the laser light wave to obtain electric current will be investigated with a SB diode having a light wave guide built into its barrier region. This type rectifier has an advantage of being able to handle a larger power than a point contact rectifier. (3) LPD Converter: This effort will be continued at a reduced level to fully understand the findings that have been obtained through FY-75. Minimal amount of experimental work will also be continued to supplement the analysis. A documentation of the LPD converter research will be completed.

W76-70384 **506-25-43**
Langley Research Center, Langley Station, Va.
HIGH RESOLUTION LASER ATMOSPHERIC TRANSMISSION RESEARCH (HIGH POWER LASER SYSTEMS TECHNOLOGY)
E. S. Love 804-827-2893
(506-21-42; 506-18-12)

The objective is to perform in-house high resolution spectroscopy of atmospheric transmission windows with tunable lasers. High power gas lasers using CO2-, CO-, DF-, and HF will be operated at high pressures (greater than 1 atm) for tuning off atmospheric absorption lines. Low power tunable diode lasers will be operated in two modes: (1) laser as source for long path transmission, (2) laser as local oscillator of heterodyne spectrometer with sun as light source. Under a university grant lasing at visible wavelengths will be studied with novel chemical laser constructed in FY-75. The influence of high pressure operation of chemical (HF,DF) lasers on cascading between vibrational levels and resulting multiline output, harmful to atmospheric transmission, will be studied. Also some effects of high intensity laser radiation on transmission and photochemistry, through excitation of higher vibrational levels, will be evaluated. The results will be coordinated with studies at DOD and ERDA.

W76-70385 **506-26-10**
Langley Research Center, Langley Station, Va.
ADVANCED EARTH-ORBITAL TRANSPORTATION AEROTHERMODYNAMICS
E. S. Love 804-827-2893

The objective of this study is to develop the aerothermodynamic technology required for the design and operation of advanced vehicle systems suitable for space or global transportation in the 1990's and beyond. The intent is to derive viable vehicle configuration concepts utilizing technologies advanced beyond the base being established by the space shuttle program. Programs designed to provide solutions to key technology issues will be designed and implemented using both ground based facilities and flight experiments (as may be accomplished through the capabilities offered by the space shuttle) as required. Candidate concepts will be evaluated through a series of analytical and experimental investigations which will include the impact of, environmental constraints such as sonic boom and the effects of variations in the atmosphere. Analytical efforts will include the development of methods for vehicle characteristics definition. Computational flow field methods will be developed with particular emphasis on realistic configurations; verification will be throught specifically designed experimental investigations. Langley facilities such as the 6-Inch Expansion Tube, the Hypersonic CF4 Tunnel, Continuous Flow Hypersonic Tunnel, the 22-Inch Helium Tunnel, and others will be used to perform parametric studies of real-gas effects, viscous interactions, vortex interactions, and convective heat transfer of a broad range of vehicle configurations and components over a broad range of flight conditions.

W76-70386 **506-26-20**
Langley Research Center, Langley Station, Va.
PLANETARY ENTRY AEROTHERMAL R&T
E. S. Love 804-827-2893

The objective is to establish the technology base necessary to assure survival and reliable performance of scientific probes during entry into the atmospheres of Mars, Venus, the outer planets, and certain natural satellites such as Titan. The technology readiness target schedule, which assumes a cutoff in technology development 3 years prior to launch, is mid 1975 for Venus (Pioneer Venus), late 1977 for Jupiter (Pioneer Jupiter Orbiter/Probe) and late 1978 for Saturn and Uranus. This target schedule is the key for the specific task milestones. The objective will be pursued using analytical and experimental methods and will be conducted primarily in-house with contract support as justified. This work will encompass the following topics: (1) studies to define hypervelocity entry vehicle heating and aerodynamic environments, and minimize radiative and convective heating and/or heat loads and optimize aerodynamic performance by choice of trajectory, vehicle, shape, etc. (2) development of aerothermal technology required for upgrading of existing facilities or design of new facilities considered appropriate to development of planetary entry aerothermal technology.

W76-70387 **506-26-21**
Ames Research Center, Moffett Field, Calif.
GAS DYNAMICS RESEARCH
D. R. Chapman 415-965-5065

The objective is to add to the understanding of high-energy fluid flow processes and the relations between such flow processes and the basic thermodynamic and transport properties of matter, including kinetic rate processes and radiative transfer in gases. Classical, semiclassical, and quantum theories will be explored to find the most efficient models for these properties in terms of the aerodynamic problems of present and potential long-lead-time NASA mission requirements, particularly in the area of processes induced in the earth's upper atmosphere by high altitude hypersonic aircraft and space shuttle type vehicles, and also in the area of problems experienced by entry probes into the planetary atmospheres, such as those which effect thermal protection and communication. These models will be tested, where possible, with experimental results. Numerical solutions using Monte Carlo statistical modeling of fluid flow will be developed which utilize the large size, speed, and parallel processing features of modern computers to calculate transport properties of gases and other flow properties. Such solutions will be used to determine the domain of validity of numerical flow field calculations based on the Navier-Stokes equations of fluid flow, and also for determining transport properties (viscosity, thermal conductivity,

and diffusivity) of reactive gases more accurately than has been possible with previous linearized methods.

W76-70388 **506-26-22**
Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL AND EXPERIMENTAL AEROTHERMODYNAMICS
Dean R. Chapman 415-965-5065
(505-06-12; 505-06-13)

The objective is to develop the aerothermodynamic technology required to define the flow field around entry vehicles. Emphasis is on the development of turbulence models from numerical and physical experiments. These models will be used in computer codes that numerically simulate the flow fields. Numerical and analytical studies will be performed to develop new turbulence models appropriate for high-speed flight and incorporate these models in advanced computer codes. Experiments at hypersonic speed specifically designed to verify these turbulence models and computer codes are to be performed. Additional experiments will be performed, as required, to define the aerothermodynamic environment for particular classes of entry probes such as the effect of moderate to massive ablation rates on transition to turbulent flow on blunt entry probe shapes. The first verification experiment will be that of an axisymmetric shock-wave-expansion interaction with a hypersonic turbulent boundary layer. The computer code planned is the complete solution of the Navier-Stokes equations including various models for the turbulent transport terms. Additional experiments will be performed as needed to verify new development in turbulence modeling and computer codes.

W76-70389 **506-26-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY PROBE DESIGN/OUTER PLANETS
R. R. McDonald 213-354-6186

This plan forms a part of the Planetary Probe Design Specific Objective of the Entry Technology Program. The assigned objective of the Jet Propulsion Laboratory to determine the dynamic behavior of outer planet atmospheric gases and atmospheric entry probe response in very high speed entry includes five tasks: (1) radiative gasdynamics, (2) boundary layer and base flow, (3) systematic performance study, (4) entry dynamics, and (5) facilities development. Since the outer planets have atmospheres consisting mainly of hydrogen and helium, most of the work performed is applicable to entry into Uranus, Saturn, Jupiter and Neptune although the speeds of entry differ. In trying to reduce the uncertainties in predicting radiative and convective heat transfer, an approach incorporating a solid theoretical foundation combined with advanced state-of-the-art experimental techniques yields the most rapid progress. Measurements of shock heated gas radiative emission and convective heat transfer are used to validate analytical and numerical models which are in turn used to compute and predict the flow-field and fluxes experienced by a proposed planetary atmospheric entry probe. Aerodynamic stability of entry probe models is to be based on various free-flight tests which provide the coefficients necessary to predict entry probe motion in a 6-deg of freedom computer program.

W76-70390 **506-26-30**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE DEVELOPMENT SUPPORT
E. S. Love 804-827-2893

This RTOP focuses Langley's expertise in configuration aerothermodynamics and operational flight mechanics on those concerns having greatest impact on successful development of the shuttle. The RTOP supports the Shuttle Program by (1) providing time in Langley ground-based facilities for direct OMSF/contractor requested support, (2) continuing independent in-house shuttle technology and development studies, (3) responding to specifically requested task-study areas from the Program Office at JSC, and (4) maintaining a strong basic aerothermodynamic supporting technology program. In addition, Langley will perform independent evaluations and assessments of the configurations and operational modes and requirements as necessary. This RTOP's program is coordinated with other NASA centers and the Phase C/D contractor through appropriate Program Office Engineering Coordination Panels at JSC.

W76-70391 **506-26-31**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: CONFIGURATIONS AND AEROTHERMODYNAMICS
Dean R. Chapman 415-965-5065

The objective is to evaluate the aerodynamic performance, stability and control and heating, of the space shuttle orbiter and launch configuration and ferry configuration to pinpoint and find the solution to aerothermodynamic problems of these vehicles in support of shuttle vehicle development by JSC and its contractors. Models resulting from contractor and in-house studies will be tested in subsonic, transonic, supersonic, and hypersonic facilities of the Ames Research Center. The wind-tunnel data will be used by NASA and shuttle contractors to evaluate the space shuttle and ferry configurations characteristics. Numerical methods and computer programs will be developed for calculating the three-dimensional chemical-nonequilibrium inviscid and viscous real gas windward flow around space shuttle orbiter configurations at angle of attack. Codes will be written for parallel and serial computers and parametric studies of shuttle entry flow fields will be performed on Illiac 4 when it becomes operational. Sufficient experimental data will be obtained to verify the correctness of the computer codes.

W76-70392 **506-91-10**
Lewis Research Center, Cleveland, Ohio.
APPLICATIONS DATA SYSTEM SUPPORT
G. Mandel 216-433-4000

The objective is to operate an Aerospace Safety Data Bank to collect, analyze, evaluate, retrieve and disseminate safety-related technical information available to all elements of NASA, its contractors and the technical community; to assure that information on the latest state-of-the-art regarding safety is available for use in planning, design, fabrication, testing and operations of aerospace vehicles and systems and associated ground facilities. ASRDI will use the resources and services of the Lewis Computer Services Division for access to the data bases. ASRDI will, also, use the resources of the NASA Facility to have its information files available for retrieval at remote consoles at every NASA installation. ASRDI will call on all elements of NASA, its contractors, and other organizations to provide basic, applied and operational data related to ground-based and flight safety experience for the Aerospace Safety Data Bank. Cooperative and exchange programs have been, and will continue to be, established with similar information activities in government and industry with the intent of utilizing existing compilations of accurate data. Liaison is being established with these activities to assure access to the information contained in these sources as needed. The information will be analyzed, verified, correlated and qualified as required. This information will be made available to all elements of NASA, its contractors, other government agencies and the technical community. Improved methods of storing, searching, retrieving and disseminating information are being developed and implemented.

Space and Nuclear System Studies

W76-70393 **790-40-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TECHNOLOGY READINESS
R. V. Powell 213-354-6586
(684-30-95)

The objective of this RTOP is to assess the readiness of technology alternatives for specific candidate planetary missions and to recommend change strategies for promising new technologies. The Mariner Jupiter Orbiter (MJO) mission will be addressed in the study with particular use of the Mariner Jupiter Saturn 1977 (MJS) technologies and designs as the technology base. The proposed introduction of block change for the MJO mission will be considered throughout the study. The approach will be to develop descriptions of the technology alternatives which appear attractive for the MJO mission, based on: proposals emanating from advanced technology areas of subsystem development groups; and logical extensions of MJS technology as defined in technology descriptions evolving from

other studies. An analysis of change introduction will be made and appropriate recommendations derived. This task will make use of the MJO mission study (684-30-95-00-10) supported by NASA (SL) during FY-75.

W76-70394 **790-40-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TECHNOLOGY ENABLEMENT ANALYSIS
R. V. Powell 213-354-6586

The objective of this RTOP is to identify and assess the enabling technical developments in the disciplines of environment control and communications which would have the greatest benefit/risk/cost potential for application to future NASA missions, including a set of shuttle launched missions. The results of this assessment will be presented as a recommendation for the development of specific technologies supported by benefit/risk/cost analyses. Areas of communications and environment control technology requiring further development to: (1) support currently projected NASA missions of the 1980's and 1990's; (2) provide greater mission capability; and (3) provide capability for missions not feasible now, will be identified. Technology identification will be accomplished by identifying the requirements of the proposed NASA missions and identifying current state-of-the-art advances that could effectively be employed by further missions. This activity will take full advantage of other separately funded work in the general area of technology projection, such as the Space Transportation System Technology (STST) and Advanced Systems Technology (AST) Working Groups for Communications and Information Systems and for Thermal Control; the General Dynamics Future Payload Technology Requirements Study, Report No. ATR-WP-004, administered by Ames, the Marshall shuttle payload study; and the NASA-wide Outlook for Space studies. Included under environment control are the disciplines of thermal control, cryogenics, contamination, and nuclear radiation, but excludes thermal protection. Included under communications are the disciplines of tracking, telemetry and command, encompassing both spacecraft and ground systems.

W76-70395 **790-40-06**
Ames Research Center, Moffett Field, Calif.
INTERSTELLAR COMMUNICATION FEASIBILITY STUDY
J. Billingham 415-965-5729
(790-91-02)

The objectives of this study are to examine the validity of, techniques for, appropriate target stars for a systematic search for intelligent life within 1,000 light years of earth. This RTOP is for a study program to examine the feasibility of interstellar communication, to select the most promising system for the search, and to develop a plan for further engineering studies. The approach will be to perform basic concept review and preliminary target star identification studies in-house (with the guidance and assistance of distinguished scientists), and also by out-of-house preliminary engineering studies. The in-house team will report directly to the Chief, Systems Studies Division, Ames Research Center. The study will capitalize on the already completed, comprehensive Project Cyclops study, and will evaluate the Cyclops proposals as one of several possible approaches to interstellar communication. Candidate system concepts will be evaluated, and the selection of a preferred system made according to major criteria such as cost, national goals, international cooperation, and contributions to science and technology, particularly radioastronomy.

W76-70396 **790-40-07**
Langley Research Center, Langley Station, Va.
ADVANCED MISSION CONCEPTS - EARTH ORBITAL TRANSPORTATION SYSTEM TECHNOLOGY REQUIREMENTS
E. S. Love 804-827-2893

The objective of this study is to identify the technology required for the design and operation of advanced earth-orbital vehicle systems for application in the post-shuttle time frame. The intent is to analyze potentially attractive concepts which build upon the technology base developed for the Space Shuttle Program utilizing projected advances in such areas as materials, structural design, and propulsion systems. Definition of approaches to advanced system design and a detailed examination of the relative impact of assumptions as to achievable levels of various technologies offers a suitable means of identifying those technologies which are crucial as well as those most cost effective; this identification will be a primary output of the effort. An inherent characteristic of any such advanced system is that it offer clear and significant cost/capability advantages relative to current systems. Programs to provide solution to key technology issues will be designed based on the results of these studies. The activity will be pursued through a series of contractual system studies, technology planning methodology development studies, and selected in-house analyses as required.

W76-70397 **790-40-11**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS ANALYSIS METHODOLOGY AND SUPPORT
D. B. Wood 301-982-2330

The objectives are to provide an improved analytical basis for OAST management decisions on R&T program planning and selection; develop and exercise techniques by which modern systems, economic and decision analysis methods can be applied to the planning process.

W76-70398 **790-40-12**
Lewis Research Center, Cleveland, Ohio.
ADVANCED HIGH PRESSURE ENGINE STUDY
John W. Gregory 216-433-4000

NASA is currently conducting studies of advanced vehicle concepts for the 1990's and beyond time period to provide direction for technology advancements to best meet future national needs and agency goals. Various single-stage-to-orbit (SSTO) shuttle vehicle concepts have been studied and appear promising as low cost space transportation systems. Such vehicles utilize high pressure rocket engine systems and may employ mixed-mode propulsion wherein high bulk density propellants are burned at take-off and low bulk density, higher performance propellants (LOX-LH2) are burned later in the flight. Studies will be conducted in FY-75 of such rocket engines to determine cooling limitations, turbopump drive cycle limitations, engine weight, and performance for various propellants and auxiliary coolants. These studies will include dual fuel engines, which are capable of burning two different fuels with LOX in the same thrust chamber. In FY-76 this study will be extended to include high pressure LOX-LH2 engines which may be used only in vacuum conditions or may operate from takeoff to orbit like the SSME.

W76-70399 **790-40-45**
Ames Research Center, Moffett Field, Calif.
SYSTEMS ANALYSIS OF POST EOS/SEOS OPERATIONAL SYSTEMS
Edgar M. Van Vleck 415-965-5898

The objective of this RTOP is to capitalize on existing and on-going study results to determine desirable technical characteristics and research and technology requirements of post EOS/SEOS earth observations systems; to identify optimal sensor complements, operational procedures, data flow patterns, orbital configurations, etc.; and to develop an understanding of total program lifetime cost impacts of key system options. The approach is to expand the studies of earth observation satellite options into the post EOS/SEOS timeframe and explore the cost-effectiveness of varying these options as to: sensor complements; data product packages; coverage frequencies; orbit; mixes of satellites; synergistic combinations of sun synchronous and earth synchronous satellites, aircraft, RPV's and in situ sensors; satellite size tradeoffs; satellite reliability/maintainability tradeoffs; spatial, spectral, and temporal resolution; user acceptance; and cost-effectiveness. The optimal technical characteristics of post EOS/SEOS operational systems will be studied as a guide to the conceptual studies, research and technology development, and experimental demonstration satellites necessary to achieve an operational system in the future.

Space and Nuclear Systems Technology Programs

W76-70400 **520-71-01**
Langley Research Center, Langley Station, Va.
SOLID STATE DATA RECORDER
J. E. Stitt 804-827-3745
(506-18-21)

The overall objective of this project is to provide, by CY-1978, a 10 to the 8th power solid state data storage system suitable for replacing tape recorders in many aerospace vehicle applications. Specific intermediate objectives are: (1) to design a 10 to the 8th power bit data recorder using bubble technology, (2) develop and demonstrate a basic recorder in a breadboard configuration, and (3) develop and fabricate a prototype 10 to the 8th power bit recorder. A two-phase developmental contract will be used to provide the 10 to the 8th power bit data storage system. This contract will be supplemented by analytical studies and laboratory investigations in critical areas of the recorder magnetic and electronic systems. These studies will be directed towards providing improved operational characteristics, longer useful life, and reduced costs.

W76-70401 **521-71-01**
Flight Research Center, Edwards, Calif.
ATMOSPHERIC FLIGHT EXPERIMENT
Jack L. Kolf 805-258-3311

The subsonic and low supersonic characteristics of a configuration representing an advanced class of entry vehicles is being studied by means of a coordinated flight and wind-tunnel test program with the X-24B. The program will yield the detailed aerodynamic characteristics of a high hypersonic L/D entry vehicle and an indication of the ability of the wind tunnel to predict these characteristics. A flight-test approach will assess the handling qualities and piloting problems of this class of vehicle while determining performance and stability and control characteristics. Energy management and approach schemes will also be investigated during unpowered flight periods.

W76-70402 **524-71-01**
Langley Research Center, Langley Station, Va.
CASTS - COMPOSITES FOR ADVANCED TRANSPORTATION SYSTEMS
R. R. Heldenfels 804-827-2042
(505-01-34; 505-02-41; 743-01-22)

The broad objective is to increase the maximum operating temperature of resin-matrix composite materials for structural applications to 600 F to meet requirements for advanced space transportation systems and payloads. The objective will be achieved through a joint in-house and aerospace industry contract effort which will (1) development and characterization of currently available polyimide resins and adhesives and new resin systems, (2) development of manufacturing and quality control procedures, (3) development of thermal structural design methods, and (4) design, fabrication and ground tests of small scale components and full-scale space structure demonstration components.

Space and Nuclear Experimental Programs

W76-70403 **750-01-02**
Ames Research Center, Moffett Field, Calif.
IMPACT OF THE SHUTTLE/SPACELAB OPPORTUNITY TO EXTEND RESEARCH AND TECHNOLOGY PROGRAMS INTO SPACE ON SPACECRAFT FAILURES AND ANOMALIES
F. F. DeMuth 415-965-5638

The objectives are: to determine if the opportunity afforded by the Space Transportation System/Spacelab to extend research and technology programs into the space environment by providing a means to conduct in situ technology experiments demonstrations or tests can have a significant input on the quantity or seriousness of anomalies exhibited in-flight by spacecraft; (1) to catalog those anomalies experienced by in-flight spacecraft when access to space could have been instrumental in eliminating the cause of the anomalies or reducing their impact; and (2) to identify those technological or programmatic areas where acess to space could have been significant in reducing the impact of in-flight spacecraft anomalies. The approach is to review and analyze, in light of the objective, the 1230 spacecraft anomalies contained in the PRC/SSC Space Data Bank.

W76-70404 **750-01-10**
Langley Research Center, Langley Station, Va.
ORGANIZATION AND MANAGEMENT OF OAST SPACE TECHNOLOGY WORKSHOP ACTIVITIES
E. S. Love 804-827-2893
(750-01-12; 750-01-31)

The objective of the OAST Space Technology Shuttle Payloads Program is to exploit the Space Transportation System (shuttle, Spacelab, tug) to accomplish innovative, cost effective research and technology investigations in the space environment which require the characteristics of space (weightlessness, vacuum, radiation, and unique location) and complement ground-based and airborne investigations. This effort addresses the organization and management of OAST Space Technology Workshop activities. The objectives are to: identify research and technology experiments which can/should be conducted in space utilizing the Space Transportation System (STS); identify technology needed from OAST by OSS, OA, OMSF, and OTDA in order to meet the objectives of their space activities; and broaden the STS user community. The approach is to: conduct an in-house NASA workshop in the summer of 1975 to identify those engineering technology areas which could beneficially utilize the STS to conduct experiments in space, and identify specific experiments; sponsor a symposium in the spring of 1976 to present NASA's thoughts (from the in-house 1975 summer workshop) to the non-NASA engineering community (other government agencies, universities, and industry); and conduct a 1976 summer workshop to obtain inputs from the non-NASA community.

W76-70405 **750-01-11**
Langley Research Center, Langley Station, Va.
ADVANCED TECHNOLOGY LABORATORY SYSTEMS DEFINITION
E. S. Love 804-827-2893
(750-01-12)

Langley Research Center in-house studies have established the feasibility of a Spacelab compatible Advanced Technology Laboratory (ATL). These designs included definition of LaRC experiments, ATL and Spacelab concepts and operational requirements. The objective of this effort is to provide a systems definition of an ATL which utilizes the NASA shuttle and European Spacelab for advanced technology investigations. The ATL will provide OAST with the capability of implementing a spaceborne research program that is truly accessible to the ground-based researcher. This primarily contracted effort will focus on major ATL program functions for the first ATL payload (ATL No. 1) such as: experiment/payload layouts, interface hardware, display and controls, data management, mission analysis, interface GSE, etc. Design analysis will also be conducted to assess the impact of Spacelab on NASA's advanced technology program. In addition, costs, schedules, and implementation plans will be defined for phased follow-on activities. Further refinement of the ATL design will focus OAST shuttle sortie research requirements and make timely contributions to the concurrent NASA shuttle and European Spacelab design activities.

W76-70406 **750-01-12**
Langley Research Center, Langley Station, Va.
ADVANCED TECHNOLOGY LABORATORY EXPERIMENT DEFINITION
E. S. Love 804-827-2893
(750-01-10; 750-01-11; 750-01-31)

The objective of the OAST Space Technology Shuttle Payloads Program is to exploit the Space Transportation System (shuttle, Spacelab, tug) to accomplish innovative, cost-effective research and technology investigations in the space environment which

require the characteristics of space (weightlessness, vacuum, radiation, and unique location) and complement ground-based and airborne investigations. The Advanced Technology Laboratory (ATL) is a set of Spacelab payloads which will provide the capability to perform multidiscipline research and technology experiments in space. The objective of this effort is to identify and define experiments to update the ATL experiment manifest. In-house studies initiated by Langley in 1972 have established the feasibility of the ATL concept. These studies included the identification and definition of 42 ATL multidiscipline experiments. This effort to identify and define additional ATL experiments will be accomplished by in-house efforts, outside consultants, research contracts, and selective procurement of experimental studies and equipment. This effort will provide experiment definition assistance and guidelines to ATL experimenters to ensure that experiments are designed to operate effectively and safely in space. The experimenter and his supporting organization will be responsible for follow-on experiment funding, development, fabrication and operation.

W76-70407 **750-01-31**
Langley Research Center, Langley Station, Va.
LDEF EXPERIMENT DEFINITION
E. S. Love 804-827-2893

The broad objective of this RTOP is to identify through contacts with the scientific community experiments which could be conducted on future Long Duration Exposure Facility (LDEF) missions. This task will be directed toward assessing demands and requirements and systems planning. Potential users will be identified and briefed on the general capabilities of LDEF. The experiments identified will be studied in sufficient detail to provide information on the scientific return, complexity, cost, and impact on LDEF mission and system characteristics. A contract will be awarded to assist LRC in this experiment identification effort. Other smaller contracts may be awarded to such areas as university research centers to assess the contribution of LDEF to their research programs.

W76-70408 **750-01-51**
Langley Research Center, Langley Station, Va.
DEFINITION OF PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE
E. S. Love 804-827-2893

This RTOP supports two parts of the total program, the Physics and Chemistry Experiments (PACE) Working Group activities and the Molecular Beam Lab (MBL) experiment definition studies. The goal of the working group is to formulate a PACE program designed to use the shuttle transportation systems to: (1) promote physics and chemistry as a laboratory science to be performed in space; (2) provide the opportunity to perform PACE experiments in space to a broad community of researchers and to encourage their participation in the program; (3) define and develop for space flight fundamental and applied PACE experiments for which the space environment is essential; (4) define and develop the facilities required to perform these experiments in space. The goal of the MBL definition studies is to define the experiment and facility concepts which will be developed and flown on space shuttle. The Molecular Beam Experiment Facility is a Wake Shield Facility modified by the addition of a hole at the apex of the cone permitting the entry of atmospheric gas. The experiment facility will be used to perform research in the fields of gas-surface interaction and in atmospheric physics. The first gas-surface research involves the initial oxidation kinetics of a clean metal surface with atomic oxygen from the atmosphere. This is important for corrosion technology, electronics, and catalysis. Precise characterization of the upper atmosphere by MBL will permit scientists to detect and understand the effects of solar wind and magnetic disturbances on the atmosphere.

W76-70409 **750-01-53**
Lewis Research Center, Cleveland, Ohio.
DEFINITION OF FLUID PHYSICS AND COMBUSTION SPACELAB EXPERIMENTS
D. A. Petrash 216-433-4000

The general objectives of the program conducted under this RTOP are to provide specific proposals for experiments to be conducted in the Spacelab of the shuttle. Analytical as well as experimental programs conducted on the ground and in the LeRC Drop Tower Facilities will provide the information from which these proposals will be drawn. During FY-74, overview studies on fluid physics and combustion were conducted by scientific experts in the private domain in order to identify areas in which worthy Spacelab experiments could be conducted. The studies to be carried out and the principal investigators involved will primarily be determined by the recommendations of these overviews. Although the majority of the research will be conducted by non-NASA personnel, some in-house work is planned in the late 1970's.

W76-70410 **750-01-54**
Marshall Space Flight Center, Huntsville, Ala.
DEFINITION OF PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE
William C. Cliff 205-453-0875

The overall objective is the conduct of definition and feasibility studies of candidate experiments, in the area of the physics and chemistry of fluids (single and multiphase), which require and utilize the unique zero or low gravity of earth orbit. The candidate experiments (tasks listed below) are motivated by the need to resolve fundamental problems and issues which are of significant importance in the areas of pure and applied physics and which relate to national needs. Individual objectives are (1) the development of a model and theory for the kinetics of the scavenging of aerosols by walls, (2) the development of a model and theory for the effects of gravity on two phase flow phenomena, (3) the development of a model and theory for diffusion due to the presence of a mass density gradient, and (4) the development of a model and theory for nucleate boiling burnout in the asymptotic limit of zero-g. The objectives shall be accomplished by developing theories and experiments for a zero-gravity environment which (1) separate gravity scavenging of particles from wall scavenging, (2) separate the gravitational slippage from accelerating slippage (relative motion) in two phase flows, (3) produce a density gradient with attendant mass diffusion, and (4) separate gravitational body forces from wetting forces.

W76-70411 **750-01-61**
Ames Research Center, Moffett Field, Calif.
ENTRY TECHNOLOGY PAYLOADS
D. R. Chapman 415-965-5065

The objectives are: to determine the feasibility of using the shuttle or a shuttle payload to advance entry technology; to identify those planetary entry flight experiments which can be conducted using the shuttle (augmented with a booster); and to define the parameters of a dedicated shuttle payload which can be used to simulate an outer planet entry and an abortive reentry of a nuclear waste disposal package. The approach to be followed in utilizing the shuttle system for achieving the objectives of entry technology is to study and assign priorities to experiments, to determine the levels of complexity of the experiments; (i.e., piggy-back experiments, or a shuttle flight dedicated solely to the experiment). Examination will be made of such questions as availability and capability of boosters, weight requirements, scheduling of experiments, costs, and impact of the experiment on the shuttle vehicle. Experiment definition will include definition of the experimental objective and the contribution it will make to the existing technology.

W76-70412 **750-01-62**
Langley Research Center, Langley Station, Va.
SHUTTLE ENTRY TECHNOLOGY PAYLOAD AND EXPERIMENT DEFINITION
E. S. Love 804-827-2893

The planned operational flight frequency of the shuttle coupled with its large payload carrying capability will provide an unprecedented opportunity for conducting aerothermodynamic research as an adjunct to orbital operations. This research capability can be separated into two categories: (1) those research experiments which will utilize the shuttle's normal interaction with it's environment during ascent and reentry; (2) those experiments which will utilize a vehicle launched from the Orbiter

for earth entry. The successful application of these experiments and the effective utilization of the shuttle flights for reentry payload launching with minimum impact on the shuttle system and primary mission objectives depends on early experiment and payload definition, development, and system integration. It will be necessary to determine in-house research requirements applicable to shuttle and shuttle-launched payloads and conduct studies to define feasibility and capabilities of various shuttle launched payloads, design launch systems, and define shuttle interfaces and mission peculiar requirements.

W76-70413 **750-01-71**
Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)
Robert J. Naumann 205-453-0940
(506-16-35; 909-54-13)

The broad objectives for the STS Induced Environment Contamination Monitor (ICEM) are to conduct an indepth survey of the potential contamination of experiments from the induced environment in and around the STS on the early Orbital Flight Tests (OFT) of the Orbiter, LDEF, and Spacelab during all mission phases in order to: (1) verify the specified requirements in Volume X of JSC 07700; (2) provide diagnostic data to identify any sources that contribute to out-of-specification conditions so that corrective action may be taken; (3) measure the contamination effects from delivery, deployment, retrieval, and landing a free-flying payload; and (4) perform routine monitoring to detect any anomalous operating conditions such as leaks in the hydraulic, coolant, or fuel system; sloughing off particulates from TPS, insulation, or experiments; outgassing from new components or various experiments, etc. Basic instrumentation concepts have been established and breadboard instruments are being procured for evaluation. A demonstration model of the IECM will be assembled and demonstrated by Oct. 1976. A proposal stage program plan for an FY-77 new start has been prepared and submitted.

W76-70414 **750-02-01**
Langley Research Center, Langley Station, Va.
LONG DURATION EXPOSURE FACILITY PROJECT
E. S. Love 804-827-2893

The broad Long Duration Exposure Facility (LDEF) Project objectives are the following: to develop LDEF, a simple, low-cost, free-flying facility for performing long duration technology and other experiments in the space environment using the Space Transportation System (STS); to develop a first set of experiments for the facility and, by the performance of these experiments, obtain valuable technological data and demonstrate the unique shuttle/LDEF capabilities and features; to broaden the STS user community by providing a simple low-cost approach to integrate and operate a large number of OAST and other unmanned long duration experiments via the STS. The LDEF is a reusable, unmanned, low-cost, free-flying structure on which many different experiments can be mounted. The facility will be delivered to earth orbit by the shuttle. After an extended period in orbit, the facility will be retrieved on a subsequent shuttle flight and returned to earth for experiment analysis. Many of the experiments being considered for the LDEF are completely passive with the active data measurements being made in the laboratory after the experiments are returned.

W76-70415 **750-03-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
DEVELOPMENT OF A SHUTTLE FLIGHT EXPERIMENT: DROP DYNAMICS MODULE
T. Vrebalovich 213-354-4530

The principle objective of this RTOP is to design, fabricate, and test an acoustic levitation and manipulation module for Spacelab and to utilize it to perform an initial set of experiments as part of the NASA Physics and Chemistry in Space Program on an early shuttle/Spacelab flight. The module is scheduled to be ready for the ESRO-NASA joint Spacelab mission, and will be available for Spacelab flights thereafter. This acoustic positioning and manipulation module will allow us to utilize the unique zero-g environment provided by a shuttle/Spacelab flight to perform drop dynamics experiments that are impossible to perform in a gravitational field. Examples are: (1) study experimentally the problems first proposed by Newton, and never satisfactorily studied, of equilibrium figures and the bifurcation processes of a rotating spheroid, and (2) understand the fission and fusion processes in drops that are also applicable to meteorology and nuclear physics. The scope of this work is threefold: (1) to determine the maximum capability of this facility within the constraints of money and schedule, through consultation with the scientific community and investigators; (2) to fabricate a flight unit, and (3) to perform an initial set of experiments, Drop Dynamics, as part of the NASA Physics and Chemistry in Space Program. The scientific community will be invited to participate in experiments informally through international symposia and colloquia. Some scientists will participate with JPL as science associates and consultants. Others will presumably submit experiments in response to NASA AFO's.

OFFICE OF ENERGY PROGRAMS

Energy Research and Technology Programs

W76-70416 **776-10-01**
Marshall Space Flight Center, Huntsville, Ala.
SPACE BASED POWER CONVERSION AND POWER RELAY SYSTEMS
Walter E. Whitacre 205-453-3465

The objective of this RTOP is to develop a data base for assessment of satellite power systems in the areas of technology, environmental impacts, costs, and competitiveness in comparison with earth based systems; and to provide thereby a sound basis for future decisions concerning satellite power systems development. Analytical and experimental investigations will be conducted under contract and in-house. These studies will be designed to identify and develop the critical technologies, assess environmental effects, develop procedures to minimize these impacts, and estimate the costs of system development and operation. Space based solar and nuclear energy sources direct and dynamic power conversion systems, and active and passive power transmission systems will be considered. The technologies will be developed directly and through the support of other projects, with the aim of removing technical, economical, and environmental barriers, comparisons will be made with conventional and advanced terrestrial power systems in the areas of performance, costs of development and operation, and major impacts; this phase of the work will be closely coordinated with studies in progress and planned at JPL.

W76-70417 **776-10-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
COMPARATIVE ASSESSMENT OF ORBITAL AND TERRESTRIAL CENTRAL POWER SYSTEMS
M. E. Alper 213-354-6948

The NASA Office of Energy Programs is presently conducting a study of the potential utility of large orbital central power stations as energy sources for terrestrial applications. As part of this study, which will continue in FY-76, a survey of potential terrestrial energy conversion systems is being made in order to provide a basis for assessment of orbital central power stations. The terrestrial systems studies include the areas of system performance, operations, costs and impact. Terrestrial power plant types include standard and advanced fossil and nuclear energy systems and several types of solar energy systems. Conventional and more advanced methods of energy transmission are also included. In conducting this study, maximum use of the existing literature is being made.

W76-70418 **776-15-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE POWER TRANSMISSION AND RECEPTION
R. V. Powell 213-354-6586

(643-60-10)

This plan continues a five-year long cooperative effort with the Lewis Research Center to answer some fundamental questions about microwave power transmission and to advance the state of the art therein. FY-76 efforts will define the properties of large-scale transmitting arrays to enable the design and development of an array that can replace the existing klystron and 85 foot diameter antenna used in the initial test. This transmitting array will be intended as a prototype of one suitable for spaceborne applications. Shuttle mission experiments in space power transmission will be designed. In particular, JPL will do the following: (1) complete the Rectenna Verification Tests using the JPL Venus-DSS-13 26m antenna and transmitter as the high power microwave illuminator; (2) obtain preliminary component phase characteristic data for DC-RF converters, RF mixers, phase locked loops, and filters; (3) perform system analysis and design optimization of a power transmitting phased array; (4) obtain breadboard phase control system performance data; and (5) develop the system specification and begin preliminary design of the microwave power transmitting phased array for the FY-78 large scale verification test.

W76-70419 **776-40-01**

Goddard Space Flight Center, Greenbelt, Md.

SOLAR IRRADIANCE DATA FOR ENERGY CONVERSION FROM METEOROLOGICAL SATELLITES

M. P. Thekaekara 301-982-5034

The objective of the RTOP is to develop and apply procedures for determining solar flux on the ground by joint analysis of satellite measurements and ground truth data. An ultimate objective is to prepare solar energy maps for the United States and its bounding waters, to be used for guidance in the optimum siting of solar power conversion systems, in solar heating and cooling of buildings, bioconversion for clean fuels production, and desalination of water. Analytical and empirical methods will be investigated for the application of satellite data in conjunction with ground truth data to the determination of ground level solar energy flux. The analytical method will take account of the dependence of ground solar flux on the insolation at the top of the atmosphere, the planetary albedo, the ground albedo, and the solar energy absorbed in the atmosphere. The empirical method will relate ground level flux to satellite-obtained imagery of the cloud cover and associated hours of sunshine. Data from previous and ongoing meteorological satellite missions will be used. These efforts will be contractual. Ground truth data determination will be performed by in-house staff.

W76-70420 **777-40-01**

Lewis Research Center, Cleveland, Ohio.

ASSESSMENT OF THE ENERGY APPLICATION OF ADVANCED TECHNOLOGIES

James R. Ramler 216-433-4000

The objectives are to identify the opportunities for application of advanced energy technologies, and assess their potential benefits and impacts to the nation, and, to identify within the technologies showing significant benefit, those in which NASA could potentially make a major contribution. The approach is to conduct in-house and contracted studies to identify and assess opportunities for advanced energy technology applications; determine the performance and costs of systems incorporating advanced energy technologies, and their benefits and impacts on the nation; compare alternative advanced technology systems which are functionally competitive. These evaluations will be conducted within the framework of the U. S. energy and economic systems and will include both national and regional considerations. Various energy and economic system projections (scenarios) will be considered based on a range of assumptions regarding such major factors as depletion of resources, population growth rate, availability of capital, and others. Since these studies will address a broad spectrum of energy related questions and technology areas, an inter-center coordinating group will be formed to insure that the interest and expertise of other NASA centers involved in energy related work will be appropriately utilized and incorporated into the overall study.

W76-70421 **778-10-01**

Lewis Research Center, Cleveland, Ohio.

ENERGY CONVERSION ALTERNATIVES STUDY

L. I. Shure 216-433-4000

The objective of this program is to provide an evaluation on a comparable basis of ten major classes of advanced stationary power conversion systems for electric utility application using coal or coal-derived fuels. The evaluation will be on a basis of energy conservation, environmental intrusion, economic viability, and natural resource requirements. The study of each of the conversion systems is being conducted under two major contracts with the General Electric Company and Westinghouse. These contract activities will be supplemented by an in-house analysis of several of these advanced systems in order to assist project management in guiding and directing the studies. The output of the contracts will be data that will be assessed in an LeRC in-house national energy system model to determine impacts and benefits on a national scale. This project is being performed by NASA for the ERDA and NSF and is jointly funded and directed.

W76-70422 **778-11-02**

Ames Research Center, Moffett Field, Calif.

HIGH-TEMPERATURE HYDROGEN ATTACK OF STEEL

D. R. Chapman 415-965-5065

The objectives are to define the effect of relevant high temperature gaseous environments on the integrity of pressure vessel steels used in planned and operating coal gasifiers and, if possible, to develop improved materials and/or operating procedures to increase the efficiency of gasification systems. The environments of concern consist primarily of gaseous hydrogen mixed with significant quantities of steam, CO, and CO2 and lesser quantities of CH4, NH3, H2S, and HCN at pressures from 15 to 1500 psia and at temperatures from 150 to 500 C. This program will be conducted in close cooperation with the Electric Power Research Institute (EPRI) and will consist of four separate components aimed at improved efficiency (reliability) of coal gasifiers. The NASA work is one component of the overall program and will concentrate on developing improved understanding of the behavior of steels in high temperature, hydrogen rich environments with EPRI concentrating on the remaining objectives. The NASA program will define not only the effects of the environments (including the anticipated important effects of minor constituents) on the kinetics of relevant surface and bulk reactions, but also will define influences of these reactions on the mechanical integrity of the steel alloys. Of special interest will be the influence of alloying additions and structural modifications to the steels. The results of these kinetic and mechanistic studies will be combined in an effort to understand and predict the rate and severity of degradation encountered in specific engineering applications.

W76-70423 **778-15-01**

Lewis Research Center, Cleveland, Ohio.

DIRECT CYCLE GAS TURBINE ENERGY CONVERSION

M. H. Krasner 216-433-4000

The objective is to contribute to development of a new Power Conversion Loop (PCL) to be used in commercial nuclear plants for base electric load applications. The plant will use a developed High-Temperature Gas-Cooled Reactor (HTGR) as a heat source. 1500 F helium available from the reactor will be used in a Brayton cycle turbine system to generate electricity. The advantages of this system stem from its ability to use dry heat rejection economically. ERDA is the funded agency for the overall program and all funds will be transferred. The approach is to manage completion of the conceptual design of a Helium Components Test Facility (HCTF) capable of testing a full-scale prototype PCL, (the facility will use a fossil-fired heater to simulate a reactor), these tests will confirm system performance, establish transient characteristics and demonstrate maintenance techniques; manage and execute programs to investigate the suitability of key HCTF components or subcomponents resulting from the conceptual design; and assist in the definition phase of a supporting base technology program for the PCL.

W76-70424 **778-20-01**
Marshall Space Flight Center, Huntsville, Ala.
EARTH BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS
W. E. Whitacre 205-453-2817

The objective is to bring to a logical and timely conclusion in FY-76 the analysis and subsystem/system designs and testing of concepts for the development of earth based electrical power generation systems utilizing insolution as the energy source. Plans for this program were formulated in CY-74 and were phased to systematically investigate concepts, subsystem designs and system problems through analysis, design development, and testing, which would culminate in an earth based solar powered electrical demonstration power plant of 100 KW capacity. Uncertainties in roles and missions affected funding almost from the beginning which resulted in limiting the scope and placing funds on high priority technology needs. Three areas were pursued: fresnel lens collector technology development, the acquisition of insolation data including procurement of an automatic insolation measuring system, and coatings (materials) technology. Subsequent events now require concluding the effort in a way that maximum value will be realized from the past work. This will be accomplished by completing the test and evaluation of a full size fresnel lens collection module (6'x12') completing the analysis of the NOAA solar flux data, testing the automated insolation measuring system to be delivered in August '75 and utilizing results of the coatings (materials) technology now in process. All activities are scheduled for completion by the end of CY 1975.

W76-70425 **778-21-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW-COST SILICON SOLAR ARRAY PROJECT
R. G. Forney 213-354-6709
(506-23-12)

The objective is to develop low cost, reliable, silicon solar array technology required for production of more than 500 MW per year at a cost of less than $0.50 per peak watt with 20-year lifetime by 1985. The plan for this program is described in the JPL document, Program Plan, Low Cost Silicon Solar Array Program, dated November 15, 1974, no. 1200-181. The Task Order is RD152-A66. This Project was initiated under the Memorandum of Understanding between National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) Concerning Cooperative and Collaborative Research Efforts on the Subject of Solar and Solar Derived Energy for Terrestrial Use, dated 27 September 1974. In December, this effort was transferred to Energy Research and Development Administration (ERDA) from where it will be administered as part of their Photovoltaic Conversion Program. The Project will assess the many competing and augmenting technologies involved in the production of arrays by soliciting Industry and Universities for their proposals including materials, solar cell formulation, encapsulation and the automation of the various steps and processes. Production quantities will also be procured for test and demonstration purposes.

W76-70426 **778-21-02**
Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC TEST, STANDARDIZATION AND SYSTEMS APPLICATION
Daniel T. Bernatowicz 216-433-4000

The Lewis Research Center will conduct for ERDA the Test and Systems Application Project under the ERDA Photovoltaic Energy Conversion Program. The objectives for this project are (1) to determine the system operating characteristics for a variety of photovoltaic systems and subsystems, (2) to prove by demonstrations that photovoltaic systems can satisfy the requirements of potentially attractive applications, (3) to devise and maintain a standard solar cell performance measurement system, and (4) to determine the endurance of solar cell arrays under terrestrial conditions. Contingent upon final agreement between NASA and ERDA, the work for FY 1976 will include construction of a System Tests Facility and testing of a breadboard residential system in it, start of design and construction of a prototype residential system, and the initiation of definition studies for a residential demonstration system. Implementation of the interim measurement method established in FY-75 will continue. The sensitivity of solar cell performance to variations in terrestrial insolation will be determined. A second Workshop on measurements will be held to establish specifications for a permanent measurement method and a suitable solar simulator. Real-time and accelerated endurance tests will be continued and studies of the failure mechanisms initiated.

W76-70427 **778-24-01**
Lewis Research Center, Cleveland, Ohio.
WIND ENERGY SYSTEMS
Ronald L. Thomas 216-433-4000

The objective of this program is to develop the technology for cost competitive wind-turbine generators (WTG's) and demonstrate a sufficient number of WTG's in actual applications so commercial implementation will begin by 1980. Wind energy represents a clean nondepleting energy source that is available in sufficient quantities to provide a significant portion of the nation's energy needs for electricity. Tests will be made on wind-turbine generators to determine performance, operating and engineering data. Studies and designs will be made of minimum cost WTG's from 50 kW to 3000 kW. WTG's with potential for min-cost will be demonstrated in actual applications. The utilities will be involved early to remove barriers to implementation. The suppliers for the WTG's will be developed early in the program to aid the transition to commercial status. This program will provide the technology base and demonstrations to lead to commercial implementation beginning by 1980. Program will also develop energy storage systems. Energy storage systems particularly attractive for use with WTG's will be identified and these storage systems will be tested with WTG's.

W76-70428 **778-30-01**
Lewis Research Center, Cleveland, Ohio.
ADVANCED SURFACE PROPULSION RESEARCH AND TECHNOLOGY
Donald G. Beremand 216-433-4000

The objectives of this RTOP are: (1) to assess the need for surface propulsion research and technology to meet a number of suggested mid-term and long-range objectives and goals for surface propulsion; (2) to define the alternative research and technology programs required to meet these goals and objectives; and (3) to establish the analytical methodology and data base required to rapidly assess the impact of new technology on the objectives and goals.

W76-70429 **778-31-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SYSTEM DESIGN PHASE, HIGH EFFICIENCY, LOW-POLLUTION ENGINE PROJECT
G. W. Meisenholder 213-354-4058

The work described in this RTOP will begin in April 1975 and will be approximately 50% complete by 30 June 1975. This RTOP is submitted for the continuation of this work. This work will build on the completed NASA sponsored concept feasibility (bottled gas vehicle) effort, the completed EPA sponsored critical evaluation of the hydrogen enriched fuels concept, the completed DOT sponsored lean combustion work, the NASA sponsored hydrogen generation technology work, and the on-going NASA sponsored engine improvement work to yield a system design for planned demonstration research vehicle. To achieve the objective of this work, the interrelated tasks described below will be accomplished: (1) establish a vehicle system design; (2) establish component and subsystem performance requirements based on this design; (3) evaluation experimentally the performance of critical components and component interfaces; (4) evaluate experimentally the performance of critical subsystems and subsystem interfaces; (5) modify the system design and component/subsystem requirements as dictated by the experimental results; and (6) result in a mature system design and a plan for the demonstration research vehicle phase.

W76-70430 **778-32-01**
Lewis Research Center, Cleveland, Ohio.
ERDA/NASA AUTOMOTIVE GAS TURBINE PROGRAM
J. A. Heller 216-433-4000

The objective of the program is to transfer current and on-going aerospace technology, particularly in the areas of turbomachinery, metallic and ceramic materials, and combustion and, by this means, to improve the fuel mileage by 30 percent beyond the planned 100 ph ERDA upgraded engine performance, while maintaining emissions below the 1978 standards, and to achieve this goal by FY 78. Current aerodynamic turbomachinery technology is being applied to the design of ERDA's new 100 pH upgraded gas turbine, and proven new technology will be retrofitted into the new engine after delivery. Results of advanced gas turbine studies will identify new technology required and guide new and on-going advanced automotive gas turbine technology.

W76-70431 **778-36-01**
Lewis Research Center, Cleveland, Ohio.
NI-ZN BATTERY/ELECTRIC CAR FEASIBILITY DEMONSTRATION
Harvey J. Schwartz 216-433-4000
(141-93-00; 506-23-24; 778-36-02)

The objective of this program is to demonstrate the feasibility of a NASA-developed nickel-zinc battery to meet performance requirements of an urban electric passenger vehicle. The program is undertaken at the request and with the guidance of the Division of Advanced Automotive Power Systems (DAAPS) of the Energy Research and Development Administration. Nickel-zinc batteries incorporating a new separator will be built by two commercial battery companies and tested in an urban electric car to a standard driving cycle recommended by DAAPS.

W76-70432 **778-40-01**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED COAL EXTRACTION SYSTEMS DEVELOPMENT
R. E. Pease 205-453-4113

The objective is to conceive and develop new concepts for efficient coal extraction from underground mines, both newly opened mines and abandoned mines with large coal deposits. The current Bureau of Mines R and D programs to improve the existing mining methods through automation and remote control techniques are targeted to satisfy the United States near term energy requirements. However, it is felt that the upper limit in production of coal by these methods will soon be realized and that entirely new methods will be required to meet the long range energy requirements of the U.S. To extract coal from an underground coal seam, there are certain basic functions that must be performed and they include: (1) cutting the coal from the seam; and (2) haulage of the coal from the working face to the mine mouth.

W76-70433 **778-41-01**
Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF AN AUTOMATED LONGWALL SHEARER
R. E. Pease 205-453-4113

The objective is to develop, fabricate and test a coal interface detector and control system for automating a bi-directional double-drum ranging shearer/loader of the type commonly used in longwall coal mining. The automatic control of the drum shearers will consist of two control functions. One function utilizing the coal interface detector, will continuously adjust the vertical position of the drums to insure maximum cutting of the coal from the seam, with a minimum penetration of the roof and floor strata. The second control function is to drive the drums on a specific trajectory to maintain the desired profile of the working coal face. The critical component in the drum vertical control is a coal interface detector (CID). The development of a CID that is reliable and capable of substained operation in the adverse environment of a coal mine will receive the major emphasis of this effort. The second control function will require the development of a practical, low cost control system for the shearer guidance. This control system will direct the drum shearers to mine fully the coal seam the desired depth of cut and maintain proper vertical and horizontal alignment of the coal face to ensure maximum production of coal for each pass of the shearer across the face.

W76-70434 **778-41-03**
Marshall Space Flight Center, Huntsville, Ala.
LONGWALL MINING SYSTEM RELIABILITY AND MAINTAINABILITY STUDY
R. E. Pease 205-453-4113

The underground coal extraction industry currently has demands upon it to increase production and provide a larger portion of the nation's energy. The longwall mining method, presently in use by the mining industry, is the most promising advanced mining method. Reliability and maintainability, however, have contributed heavily to the prevention of longwall mining from reaching its full potential. This study will apply the analytical techniques of reliability and maintainability analysis to the goal of increasing coal production. The expected term of the task is ten months.

W76-70435 **778-51-01**
Lewis Research Center, Cleveland, Ohio.
REDOX ENERGY STORAGE SYSTEM
Harvey J. Schwartz 216-433-4000

This RTOP covers a joint program between the ERDA (lead agency) and the NASA to demonstrate a 100 KW Engineering Model System of a low-cost bulk energy storage system based on the Redox Flow Cell by FY 1981. The unique features of the redox flow cell allow bulk energy storage systems to be built in any size and sited almost anywhere. Key technology areas such as the ion exchange membrane separator, evaluation of electrochemical couples, and system optimization will be investigated through suitable electro-chemical experiments, materials developments, design studies, and laboratory tests.

W76-70436 **778-54-01**
Lewis Research Center, Cleveland, Ohio.
ENERGY STORAGE SYSTEMS TECHNOLOGY
D. L. Nored 216-433-6948

The objective of this program is to extend aerospace-derived energy storage technology to terrestrial applications. Technology developed by NASA may apply to utility, industrial, commercial, and residential energy storage. Examples of NASA programs that relate directly to terrestrial energy storage include Brayton-cycle space power systems using thermal energy storage, flywheel systems for orbital attitude control and energy storage, hydrogen fueled power systems, hydrogen storage and combustion, and the development of high pressure ratio compressors and high temperature turbines. These technologies will be used to define energy storage concepts, systems, and applications which support and complement ERDA's energy storage programs. Candidate energy storage concepts to be investigated include compressed air, flywheels, thermal storage and hydrogen. An assessment of their operational and economic characteristics, potential impact and benefits, and technology requirements along with a critical comparison of alternate approaches, will be completed in FY-76. Supporting systems and technology studies, and preliminary experimentation, will be conducted to establish the feasibility of concepts for electric utility peak-leveling systems and other energy storage applications. Technology development and demonstration programs will be formulated for promising concepts. Results will be forwarded to ERDA for their use in formulating and implementing conservation R and D programs.

W76-70437 **778-60-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HYDROGEN ENERGY SYSTEMS TECHNOLOGY PROGRAM DEFINITION STUDY
M. E. Alper 213-354-6948
(778-60-02; 778-60-03)

The Hydrogen Energy Systems Technology (HEST) Study conducted under this RTOP outlined a preliminary PDP for a Federally coordinated Hydrogen Energy Systems Technology Program to begin in FY-77. This was presented to the NASA Office of Energy Programs in June 1975 for their review and consideration. During the first quarter of FY-76 the HEST Team at JPL will support OEP in the documentation and refinement of the PDP for FY-77 and beyond. Work under this RTOP during FY-76 will also emphasize the investigation and initiation key elements of hydrogen energy research and technology identified

during the HEST Study and in which JPL has special capabilities. Primarily in the category of hydrogen production, the work will include investigations of (1) a relatively low temperature thermochemical cycle using inexpensive materials such as limestone as a feedstock, (2) kinetic rates in thermochemical cycles, (3) increased current densities from pulsed electrolysis, (4) microbiological production of hydrogen, (5) thermochemical cycle interfaces with nuclear reactors, (6) reversible storage of hydrogen in low cost aeromatics, (7) recovery of hydrogen from hydrogen sulfide, and (8) tests of specific devices to generate performance data. This work will serve to identify areas of significant payoff in hydrogen technology, begin key work prior to the FY-77 federally coordinated program start, and focus in-house capabilities on hydrogen technology problems of potential national interest, initiating an R and T base for the solution of these problems.

W76-70438 **778-70-01**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MULTI-PURPOSE GAS TURBINE TECHNOLOGY
R. P. Migra 216-433-4000

The objective of this effort is to define an advanced ground-oriented gas turbine technology program of broad applicability leading to a substantial improvement in performance (fuel savings), adaptation to alternate fuels such as coal or coal derivatives with minimum pollution and have obvious benefit to the nation's energy needs. A coordinated program meeting the needs of the various government agencies and industry suppliers would eliminate duplicative efforts. Technology advances having application to the full range of gas turbine power levels and uses would result in maximum impact at minimum cost. A secondary objective of this RTOP is to initiate proof-of-principle experiments, important studies and technology evaluation in FY-76 using NASA funding in those areas where NASA-developed technology from aero and space appear to be applicable. The continued planning and new technology efforts will provide the base for a comprehensive gas turbine technology program. The general approach will be to make use of an in-house Lewis team of gas turbine component and system experts to define technological areas that need to be advanced, have a wide range of applicability, and have obvious benefits to the nation.

W76-70439 **778-91-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HELICAL SCREW EXPANDER PROJECT
M. E. Alper 213-354-6948

The purpose is to evaluate the mechanical and thermodynamic characteristics of a commercial-size (1 megawatt) Lysholm-type helical rotary screw expander utilizing total brine flow from liquid-dominated geothermal fields. The expander to be used as a prime mover for low-cost electrical power generation from high-salinity resources which because of scaling and corrosion have not presently been exploited. The plan for this program is described in JPL Proposal 151-330, titled A Project to Evaluate and Characterize a Helical Rotary Screw Expander Power System for Electrical Power Generation from Geothermal Brine--Phase 'I', dated June 26, 1974. This project is to be accomplished under funding by the Energy Research Development Administration (ERDA). The initial phase (Phase A) is to purchase and prepare a commercial-sized single-stage rotary screw expander power system module for testing and evaluation on high-enthalpy geothermal brine. During fabrication of the module, test sites will be evaluated and selected and the planning and preparations for the second phase (Phase B) testing of the system will be carried out.

OFFICE OF APPLICATIONS

Weather and Climate

W76-70440 **175-10-10**
Ames Research Center, Moffett Field, Calif.
SEVERE STORMS AND LOCAL WEATHER RESEARCH
D. R. Chapman 415-965-5065

The objective is to investigate the utility of satellite and airborne observations to local weather and its effect on atmospheric composition problems. The approach will be to continue development of the MESO-MET computer program to model mesoscale meteorological and dispersion problems, primarily in the area of coastal phenomena and of stagnation conditions on urban scales, and to use these models to evaluate methods of interpreting and applying remote observations, to define additional capabilities desirable in future satellites, and to investigate the use of such observations in developing, improving, and extending the MESO-MET model.

W76-70441 **175-10-30**
Langley Research Center, Langley Station, Va.
SEVERE STORMS AND LOCAL WEATHER RESEARCH
E. S. Love 804-827-2893
(175-10-40; 174-30-40)

The technical objective is to develop numerical models for the movement, growth and behavior of severe local storms. Continued development of the present Langley model to determine analytical solutions for the movement, growth, and behavior of thunderstorms, tornadoes, and hurricanes will be stressed. These solutions will be validated with aircraft and satellite data and numerical solutions applied to study the structure of the storm. Expected results are: (1) method for detecting tornado cyclones from satellites, and (2) models for forecasting the location, time, and intensity of any tornadoes generated by a tornado cyclone.

W76-70442 **175-10-40**
Goddard Space Flight Center, Greenbelt, Md.
SEVERE STORMS AND LOCAL WEATHER RESEARCH
W. E. Shenk 301-982-5948
(175-10-70; 175-10-30)

The objectives are to: (1) develop improved objective methods to detect and predict severe storms and mesoscale phenomena, (2) obtain a better understanding of storm dynamics, and (3) specify new satellite capabilities for detection and understanding of these phenomena. The overall approach is to synthesize measurements of severe storms and mesoscale phenomena and their environments and to study these data using numerical and statistical models wherever possible. The measurements will be obtained from satellite, aircraft, and conventional sources. Special processing systems will be used to extract parameters to be used in models. Coincident with these efforts, new aircraft sensors will be developed and tested to provide new or improved data pertinent to the understanding and detection of severe storms and mesoscale phenomena. The results of various research approaches (case studies, modeling) will be synthesized for a systems approach to the problem of severe storm detection and prediction. The expected results of the program are: (1) a collection of the most complete and correlated set of data available to date on severe storms, (2) new techniques for extracting vital parameters from available measurements, (3) development and test of sensors to provide new data, especially from satellites, (4) verification or rejection of hypotheses on the structure and dynamics of severe storms leading to a better understanding of them, and (5) improved objective methods of detection and forecasting severe storms using modeling techniques.

W76-70443 **175-10-70**
Marshall Space Flight Center, Huntsville, Ala.
SEVERE STORMS AND LOCAL WEATHER RESEARCH
William W. Vaughan 205-453-3100
(175-10-40; 645-10-01)

Using correlative atmospheric measurements from satellites, aircraft, radar and ground based sensors, determine to what extent satellite observed data can be used to detect and describe mesoscale phenomena - especially severe storms. Make assessments of satellite data and, where appropriate, improvements in interpretation techniques and identification of current sensor limitations or potentials. Conduct the research necessary to explore the theoretical basis of cloud microphysical processes relative to low gravity experiment potentials. Explore various experiment system components and accomplish the necessary research investigations to provide the required technology for use in

developing the initial and future shuttle flight experiment payloads. Using results of MSFC developed flight laser Doppler system, determine its applicability to severe storms research and develop the system if proven feasible. To accomplish these objectives, the following tasks will be performed: (1) Task-61: structure and dynamics of mesoscale systems; (2) Task-11: theoretical studies of microphysical processes; (3) Task-41: warm cloud experiment technology development; (4) Task-42: cold cloud process experiment technology; and (5) Task-21: laser Doppler flight system.

W76-70444 **175-20-30**
Langley Research Center, Langley Station, Va.
DAILY WEATHER RESEARCH
J. E. Stitt 804-827-3745

The objective of this work is to investigate the application of microwave/millimeter wave techniques to the weather and climate discipline which relates to the sea-air interface. The research will concentrate upon radiometer hardware performance and radiometric data analysis and interpretation. The approach to the hardware phase is to develop near octave bandwidth, swept frequency microwave and millimeter wave radiometers having low noise characteristics and high efficiency antennas for use on aircraft and space shuttle. The approach to the analysis is to conduct controlled experiments with a wave tank and to utilize field data for establishing a unique correlation between the radiometric signature and the physical characteristics of the wind-driven ocean surface. This work will provide techniques for measurement and separation of surface parameters. For example, the isolation of the emission from ocean foam will yield independent measurements of surface temperature and surface wind speed.

W76-70445 **175-20-40**
Goddard Space Flight Center, Greenbelt, Md.
MULTISCALE METEOROLOGICAL RESEARCH
John S. Theon 301-982-5249
(175-10-40; 175-30-40; 175-40-40; 175-50-40)

The objectives are: to improve remote sensing techniques for observing multiscale meteorological parameters; to develop, test, and calibrate new remote sensing instrumentation required for such observations; and to demonstrate the application of meteorological data from such satellites as Nimbus, ATS, and SMS to the solution of outstanding meteorological problems involving multiple spatial and temporal scales. Studies of radiative transfer problems including numerical modelling and involving gaseous and particulate constituents, polarization, reflection, absorption, and transmission in the atmosphere will be conducted utilizing laboratory measurements, balloon, aircraft, and satellite observations. These studies will seek to improve the remote sensing of atmospheric temperature profiles, sea surface temperatures, ocean roughness, surface winds, atmospheric moisture and snow and ice cover. Systems to support the required aircraft and spacecraft sensors and provide the efficient acquisition of the data produced will be developed. Laboratory facilities to calibrate, evaluate, and test remote sensors will be supported. Data from such satellites as Nimbus, ATS, and SMS as well as from balloon and aircraft will be analyzed to determine the spatial and temporal distributions of atmospheric temperature, cloud cover, snow and ice cover, the earth's radiation budget and the interannual variations of these indices. Improved techniques for the determination of: atmospheric temperature profiles; cloud amount and height; atmospheric moisture distribution; sea surface roughness and temperature; and the radiative energy budget are expected. These improvements will result from advances in sensors, in the analyses of the data, and in supporting theories.

W76-70446 **175-30-40**
Goddard Inst. for Space Studies, New York.
STUDIES IN THE APPLICATION OF SATELLITE DATA TO LONG-RANGE FORECASTING AND CLIMATE PREDICTION AT COLUMBIA, CUNY, NYU, AND MIT.
M. Halem 212-678-5618

The objective of this research program is to develop methods for the utilization of meteorological satellite data for application to long-range forecasting and studies of climate change. Part of the program covered by the RTOP involves grants to New York-area universities for work in direct support of GISS meteorological projects. The work is performed on GISS premises by advanced graduate students and research associates from the universities involved, working under supervision of members of the GISS staff holding adjunct faculty appointments. These research assistants and associates make up the on-site junior-level scientific staff at GISS. Major projects conducted jointly with nearby university personnel under this RTOP include: (1) analysis of climate satellite data; (2) stochastic dynamic forecasts (monthly) from climate data sets; (3) studies of feedback mechanisms leading to droughts and deserts; (4) physics of atmosphere-ocean interactions; (5) development of theoretical models for studying climate change; (6) development of initialization and balancing schemes for the assimilation of satellite sounding data; and (7) mathematical and numerical analysis support in the application of long-term integrations for climate prediction. The collaboration between New York-area universities, MIT, and GISS is the backbone of the scientific resources required to carry out the program objectives laid out in the GISS 5 year meteorological plan.

W76-70447 **175-30-50**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GLOBAL WEATHER RESEARCH
D. P. Burcham 213-354-3028

This research is geared to providing a detailed understanding of the exchange of heat (both latent and sensible) and momentum between the atmosphere and a snow cover and the employment of that knowledge in parameterizing that interchange for a general circulation model (GCM) of the atmosphere. The study expects to include all heat transfer mechanisms at the surface, i.e. the conduction of heat through the snow into the ground, the turbulent exchange of heat from the surface, the radiation balance in the atmosphere above the snow and at the snow surface, and the latent heat transfer through evaporation and melting of snow. This involves a detailed numerical model describing the above processes and possibly some experimental data to verify results.

W76-70448 **175-40-10**
Ames Research Center, Moffett Field, Calif.
CLIMATE RESEARCH
D. R. Chapman 415-965-5065
(176-10-11)

Long range goals are to assess the sign and magnitude of climatic variations induced by changes in the amount of various atmospheric aerosols, trace gases, and solar spectrum. The effects of both natural and man-made perturbations will be considered. A combination of laboratory measurements, theoretical modeling, and comparison with records of past climatic variations will be utilized to assess the possible climatic effects of contaminant emissions into the atmosphere. Laboratory measurements will be made of the radiative properties of candidate contaminants. These include the specification of the optical properties of aerosols of interest. The theoretical modeling includes the development of radiation and dynamical models that will be applied on local, regional; and global scales. Studies of records of past climatic change, as illustrated by the investigation of polar ice cores, will supply clues on the causes of past climatic change, as well as permit an assessment of the models. The use of remotely sensed parameters in the climatic models will be stressed, and techniques will be developed to determine some of the important model parameters by remote sensing measurements. The sensitivity of the models to variations in the parameters they utilize will be assessed.

W76-70449 **175-40-30**
Langley Research Center, Langley Station, Va.
CLIMATE RESEARCH
E. S. Love 804-827-2893
(683-75-32)

The principal objectives are to adopt existing methods, materials, and flight hardware to the development of an accurate, but inexpensive, satellite system for measuring the earth radiation budget. The satellite system will provide the long-term characteristics of the earth-ocean-atmosphere system and will emphasize

the understanding of the physical basis of climate. These measurements are also important to determine the direction of climate change (warming or cooling), and thereby assess the effects of pollution. It will be necessary to continue these measurements for perhaps two solar cycles (about 22 years) in order to assess both short- and long-term trends. Studies of existing data will be used in planning and designing the experiment. Plans for reducing and analyzing data for the long period will be developed, and climate modeling established.

W76-70450 **175-40-40**
Goddard Space Flight Center, Greenbelt, Md.
CLIMATE RESEARCH
D. F. Heath 301-982-6421

The principal objectives are: (1) the development of a climatology of the stratosphere from satellite observations of ozone and stratospheric temperatures which are subsequently used in the investigation of large scale stratospheric processes and solar-meteorological phenomena. (2) Measurements of the temporal variability of the solar constant and spectral irradiance with an accuracy sufficient for climatological research. The approach to be used is the use of the five years of ozone observations from the BUV experiment on Nimbus 4 and the stratospheric temperature data from the SCR experiments on Nimbus 4 and 5 to develop a climatology of the stratosphere. This global data set of stratospheric ozone and temperature data will be used to investigate stratospheric warmings, meridional transport, circulation, and the role of the stratosphere as a connecting link between the tropospheric phenomena and the interplanetary solar magnetic field sector boundary passages identified in solar meteorological phenomena. These results will be combined with other stratospheric trace constituent soundings to assess the seriousness of anthropogenic pollution of the stratosphere. Periodic flights of solar constant and spectral irradiance and atmospheric radiance experiments on aircraft operating in the stratosphere will be made assessing the temporal variability of the solar constant and solar flux and the UV solar flux divergence in the photochemical region of the stratosphere. The expected results from this effort will include: (1) development of a climatology of the stratosphere. (2) determination of the magnitude of solar flux variability as a climate parameter. (3) fundamental research into stratospheric processes, circulation and its role as a connecting boundary in solar-meteorological investigations.

W76-70451 **175-40-50**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CLIMATE RESEARCH
D. P. Burcham 213-354-3028
(175-30-50)

The location and duration of snow and ice cover are recognized to be some of the most important variables in the earth's heat balance, since the albedo of ice and snow is about 80% while the albedo of bare ground and open water vary from about 5% to 20%. Changes in the ice and snow cover can have a significant effect on weather and climate. Kukla and Kukla (1974) showed that a large increase in the snow and ice cover occurred in 1971 and later, which may have been related to the anomalous global weather patterns in 1972. Monitoring of the extent of snow and ice can help to predict future weather and climate changes. A better knowledge of the changes in the snow and ice cover in the past few years, when these interesting changes were noted by Kukla and Kukla, can help to understand the mechanism relating these variables to the weather. Previous analyses have been made using data from NOAA satellites. However, these analyses have used data which have been degraded in resolution and number of brightness levels, and have had as much as a 5-day error introduced into the time that changes occurred. This study will develop techniques for the best use of satellite data for snow and ice mapping using the JPL image processing lab, and will reanalyze some of the older data to evaluate the magnitude of errors introduced by degradation of data. This study is undertaken in cooperation with Dr. George Kukla of the Lamont-Doherty Geological Observatory of Columbia University.

W76-70452 **175-40-60**
Wallops Station, Wallops Island, Va.
CLIMATE RESEARCH - OZONE MEASUREMENTS
A. C. Holland 804-824-3411
(176-10-61)

The objective is the improvement of techniques for the measurement of atmospheric ozone. The approach will be to: (1) Study improvements in optical methods for measuring atmospheric ozone using Monte-Carlo simulation of radiative transfer through the atmosphere. Assess errors or limitations in measurements due to scattering and/or absorption by molecules and aerosols. Perform studies to determine optimum instrument design parameters with necessary design modifications to satisfy future requirements for routine synoptic measurements of ozone. (2) Perform evaluation and intercomparison of satellite-borne, aircraft-based, balloon-borne and ground-based sensors for the measurement of ozone. Determine the degree to which these different techniques are capable of giving consistent results. (3) Use the ground-based, balloon-borne and aircraft-borne ozone measurement systems to provide correlative (including in-situ) truth data for the calibration and validation of rocket and satellite borne ozone sensors. For example, the limb radiance inversion radiometer (LRIR) scheduled to fly on Nimbus F to measure ozone profiles from 15 km to 60 km.

W76-70453 **175-40-70**
Marshall Space Flight Center, Huntsville, Ala.
CLIMATE RESEARCH
William W. Vaughan 205-453-3100
(175-40-40; 175-40-10; 175-40-60)

Based upon previous MSFC global reference atmospheric model development efforts, expand and improve the model to provide a reference for use in evaluating and improving numerical models of climatic change. Satellite and ground-based data will be used to develop the physical statistical atmospheric model. Develop theoretical geophysical fluid flow models for simulation of atmospheric and oceanic circulations with goal to providing scientific base for future shuttle sortie experiment/payload. Conduct research on a solar-climatic model with view to furthering the development and testing of model relationships between solar activity and climatic (precipitation, etc.) patterns and climatic dynamics. To accomplish these objectives, the following tasks will be performed: (1) Task -41: simulation and modeling of geophysical flows, (2) Task -61: solar-climatic relationships, and (3) Task -71: climate model.

W76-70454 **175-50-40**
Goddard Space Flight Center, Greenbelt, Md.
PROGRAMMATIC SYNTHESIS AND AUGMENTATION
E. A. Neil 301-982-6291

The objective of this RTOP is to provide financial support to the NASA Meteorology Program Office (MPO) in the conduct of its business in support of the Office of Applications and the various program offices represented. Results of efforts under this RTOP will be used in performing evaluations, providing recommendations, and developing future plans for NASA's weather and climate mission and programs. Funding will be utilized in-house and through available support services contractors for selected efforts in fulfilling the objectives of the MPO as defined in its charter. Studies will be focused on emerging technology so as to expedite its application and on future requirements so as to identify areas requiring initiation of new technology development. Functional expertise available at GSFC and other Centers involved in weather and climate activities will be drawn upon to the maximum extent possible. Technical and programmatic conferences as required from time to time by NASA Headquarters will be arranged and supported, and information resources to support program planning/evaluation activities will be developed and maintained. Reserve funding for contingencies or augmentation of other UPN 175 RTOPS is also provided.

Pollution Monitoring

W76-70455 **176-10-11**
Ames Research Center, Moffett Field, Calif.

GLOBAL STUDY OF STRATOSPHERIC CONSTITUENTS
D. R. Chapman 415-965-5065
(505-03-04; 743-02-22; 175-40-10)

Goals are to precisely assess effects of pollutants on composition, dynamics and structure of the stratosphere; measure global distribution of trace constituents, aided by theoretical studies and interpretations; assist in evaluation of satellite remote sensing experiments to monitor the stratosphere. These goals are to be achieved by means of model studies and by making physical measurements in the upper atmosphere. Theoretical models of the global stratosphere are being used to calculate the effects of pollutants, with special attention to anthropogenic sources, on the environment, particularly on stratospheric ozone. 1-, 2-, and 3-dimensional chemical-dynamical models are being used, modified or developed to provide assessments of such sources as fleets of supersonic transports or industrial halocarbons. Interpretation of model results provides a basis for evaluating and interpreting in situ and remote sensing experimental programs. Airborne measurements of O3, NO, and aerosols are being made seasonally and in northern, temperate and tropical regions to determine the variations of these constituents for model interpretation and verification. Additional natural constituents and pollutants require simultaneous measurement to deduce interactive processes which may affect the ozone shield globally. New instruments to measure NO2 and O are being developed in this program. Instruments for measurements of other critical constituents are being developed in other programs, but their application will also greatly benefit this activity.

W76-70456 **176-10-31**
Langley Research Center, Langley Station, Va.
STRATOSPHERIC RESEARCH PROGRAM
J. E. Stitt 804-827-3745
(176-10-32; 176-20-31)

The objective of this work is to improve our knowledge and understanding of the stratosphere by developing advanced sensors to allow broad surveys of atmospheric constituent distribution, by research into, and modeling of, the transport dynamics and constituent photochemical reactions in the stratosphere. The sensor development work includes the design of an improved limb-scanning infrared remote sensor to measure vertical distribution of stratospheric constituents important in ozone depletion chemistry. This work includes SRT on detector coolers and elevation scan and azimuth pointing servo systems, and detailed optical, thermal and radiometric analyses of the sensor, with a laboratory test program to verify the results. A feasibility study of a near-IR-correlation instrument to determine the vertical distribution of stratospheric HCl based on solar attenuation measurements will also be performed. This effort under stratospheric modeling includes an evaluation of the relative roles played by aerosols and ozone depletion on the atmospheric thermal balance (and climate). Previously developed one-dimensional photochemical models will be applied to determine the impact of injecting Cl, NOx, and H2O into the stratosphere. Coupled multi-dimensional dynamics model will be completed, and studies of interactions between troposphere and stratosphere performed.

W76-70457 **176-10-32**
Langley Research Center, Langley Station, Va.
LANGLEY RESEARCH CENTER-GEORGE WASHINGTON UNIVERSITY ENVIRONMENTAL MODELING PROGRAM
E. S. Love 804-827-2893

The objective of this work is to conduct an educational and research program the purpose of which is: (1) to expand the environmental modeling activities at Langley in a manner which directly supports the Office of Applications' remote sensing activities, Langley Research Center's involvement in the NIMBUS-G satellite experiments, and other environmental modeling activities at Langley: (2) to strengthen and expand the research and educational opportunities within Langley; (3) to increase the quality and number of trained research scientists in the area of environmental modeling; and (4) to promote cooperation between NASA, and other organizations and agencies involved in this work area (EPA, NOAA, etc.). The approach taken to accomplish these objectives will be to establish a research and education program in environmental modeling in conjunction with university senior faculty members and qualified graduate research assistant scholars. The faculty and research assistants will conduct research in conjunction with Center professionals which is supportive of the needs of Langley and the Office of Applications. The research and educational efforts of the research assistants will lead to a Master of Science degree upon completion of the basic requirements, normally two years. The program will be managed by a coordination committee of university personnel.

W76-70458 **176-10-41**
Goddard Space Flight Center, Greenbelt, Md.
STRATOSPHERIC RESEARCH PROGRAM
D. F. Heath 301-982-6421

The principal objectives are: the use of a 2-D photochemical model in conjunction with satellite derived ozone and temperature fields to investigate photochemical effects, meridional circulation and transport processes between the hemispheres, and large scale stratospheric processes; the development of a 3-D quadrupole mass spectrometer to search for new stratospheric trace constituents; and the development of a fast detector for stratosphere water vapor. The approach is to use an existing 2-D photochemical model with existing satellite and rocket data on constituents and structure to understand the physical processes which govern the stratosphere. A 3-D quadrupole mass spectrometer will be built and flown aboard an airplane operating in the lower stratosphere. A new water vapor measurement technique will be tested and flown on board an airplane and then a balloon. The expected results are concerned with providing new knowledge in such areas as stratospheric warmings, polar night and equatorial processes. Eventually a survey will be made of the stratospheric trace constituents which could affect the stability of the ozone layer.

W76-70459 **176-10-42**
Goddard Inst. for Space Studies, New York.
ATMOSPHERIC MODELING OF POLLUTION TRANSPORT
Richard W. Stewart 212-678-5579

The objectives of this research are to utilize mathematical models: (1) to aid in the interpretation of satellite and aircraft data on atmospheric composition and to assist in establishing sensor requirements for future missions, (2) to assess the impact of aerospace and industrial activities on the atmosphere. The approach is to develop increasingly comprehensive and self-consistent models for the description of atmospheric phenomena in both the stratosphere and troposphere. The initial models describe the distributions of chemical species in the atmosphere on urban, regional and global scales for prescribed thermal and dynamic atmospheric properties. Intermediate models will couple solution of the energy balance equation to that for the species continuity equation to obtain thermally consistent results. Advanced models will, in addition, calculate radiative and dynamic properties of the atmosphere and thus be fully interactive. Expected results include: (1) an assessment of SST, space shuttle, and ground-level industrial activity on stratospheric ozone levels, and (2) the development of operational urban and regional scale pollution models for describing the effect of specified ground-level pollution sources and for conducting simulation and sensitivity studies for projected remote sensing experiments.

W76-70460 **176-10-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STRATOSPHERIC RESEARCH PROGRAM
D. P. Burcham 213-354-3028
(645-20-02; 743-02-22)

The composition of the atmosphere over a large portion of the Northern Hemisphere will be investigated by means of remote infrared sensing techniques in a series of aircraft and balloon flights extending over a period of three years. The objective of the observational program is to obtain a complete inventory of atmospheric trace constituents and pollutants with a sensitivity extending down to the 10 to the minus 10th power to 10 to the minus 11th power by volume range, and to study their

three-dimensional and temporal variation in the troposphere and stratosphere. The experimental approach involves the use of a very high resolution (0.05/cm) fast Fourier interferometer spectrometer to obtain absorption spectra in the 1 to 9 micron region in short time intervals (approximately 200 sec). The instrument will be mounted in aircraft flying at altitudes ranging from 1 km to 20 km. Observations will be made by viewing the earth's surface in the nadir mode to study tropospheric composition, and by observing the sun through long atmospheric paths traversing the stratosphere in the horizontal-looking mode. Balloon flights will be conducted for stratospheric observations in the 20 to 45 km altitude range with solar observations as well as in the nadir mode. In addition to the construction of an improved (Mark 2) version of the existing High Speed Interferometer and its integration into the U-2 and CV 990 aircraft and the balloon gondola, the work includes the observational program using these platforms and the analysis and interpretation of the data obtained from them.

W76-70461 **176-10-61**
Wallops Station, Wallops Island, Va.
DETECTION, CHARACTERIZATION AND ANALYSIS OF ATMOSPHERIC AEROSOLS
A. C. Holland 804-824-3411
(175-40-60; 175-40-61; 185-47-94)

The objective is to develop the analytic techniques necessary to interpret remotely sensed data on the atmospheric aerosol; and to develop the models necessary to evaluate the impact of atmospheric aerosols on the earth's albedo. Models of radiative transfer through the earth's atmosphere for both plane wave and finite beam illumination will be developed and tested. The model atmospheres used will be (1) plane-parallel, stratified, and (2) spherically symmetric, stratified models. These simulations will be used to determine the best strategies for the remote detection of atmospheric aerosols using both passive and active techniques. The models will further be used to calculate the effect of varying amount of atmospheric aerosols on the earth's radiation budget.

W76-70462 **176-10-62**
Wallops Station, Wallops Island, Va.
INVESTIGATIONS OF STRATOSPHERIC CONSTITUENTS
T. Shardanand 804-824-3411
(176-11-61)

The objective of this RTOP is to carry out an integrated laboratory study in order to determine the spectroscopic and chemical kinetic data which are important to stratospheric studies. In the later part of the program the data obtained in this investigation will be used for photochemical modelling of the stratosphere. Also, these data (absorption and scattering coefficients, chemical rate coefficients etc) are important to assess the effects, to detect and quantitatively determine the amounts of minor constituents in the earth's atmosphere. Although the bulk of absorption coefficient data for most of the individual gases do exist, a careful consideration is required in their use when more than one gas are simultaneously present and subject to photochemical changes. However, our knowledge of photon scattering (Rayleigh, Raman, Resonance-fluorescence) is very meager. Therefore, we intent to obtain the absorption data in simulated conditions of photochemical equilibrium (dynamic and/or static) for chemically active constitutents (oxygen, ozone, oxides of nitrogen, chlorine and hydrogen...). For this purpose the multiple gas cells in series which can be connected to each other for reactions to occur will be utilized. The study of photon scattering will also be an integral part of this program to obtain the spectroscopic data of electromagnetic radiation interaction with atmospheric constituents. Also, the data obtained in this study will be used in the photochemical scheme for ozone.

W76-70463 **176-20-11**
Ames Research Center, Moffett Field, Calif.
TROPOSPHERE AIR POLLUTION MODELING AND REMOTE SENSING EVALUATION
D. R. Chapman 415-965-5065
(175-10-10)

The objective is to develop, test and utilize a chemical kinetic dispersion model which can be economically used with the ARC three-dimensional mesoscale meteorological model (MESO-MET) to simulate air pollution in the presence of complex terrain. The approach will use existing chemical kinetics models in a three-dimensional, time dependent Eulerian dispersion model by reducing their computation cost to a minimum while retaining their simulation capabilities. This dispersion model will then be incorporated in MESO-MET and used to model air pollution phenomena in a complex area to demonstrate and verify its simulation capabilities. The total MESO-MET/dispersion model will then be used to investigate in a realistic manner the interpretation of observations from remote pollution sensors, and to define desirable future capabilities of remote observations of mesoscale and regional scale air pollution.

W76-70464 **176-20-31**
Langley Research Center, Langley Station, Va.
REMOTE MEASUREMENT AND MODELING OF TROPOSPHERIC POLLUTANTS
E. S. Love 804-827-2893

The objective of this RTOP is to evaluate the role and capabilities of airborne and spaceborne remote sensors for monitoring air quality on urban-to-global scales. Measurement technology development is a major portion of the current tropospheric program but the program also includes work on numerical modeling and statistical techniques to aid in the interpretation of remote sensor data. The sensor development work begins with the definition of observables (e.g., spectral characteristics, and radiative models) and proceeds through evaluation of measurement concepts and techniques applicable to both aerosol and molecular pollutant monitoring. Emphasis in the aerosol measurements area will be on establishment of inversion schemes for the visual polarization measurement technique. Molecular trace constituent sensor work will continue to emphasize passive techniques such as the gas filter correlation analyzer (MAPS NIMBUS) and correlation interferometer (COPE) instrument for total gas burden, but studies started in FY 75 to evaluate active (LIDAR) techniques for profiling measurements will also continue. In the numerical modeling area, work will concentrate on regional-to-urban scale models for dispersion studies and work on statistical analysis techniques will continue as required to aid interpretation of aircraft and satellite sensor data.

W76-70465 **176-20-32**
Langley Research Center, Langley Station, Va.
DEMONSTRATION TESTING OF TROPOSPHERIC SENSORS ON URBAN AND REGIONAL SCALES
E. S. Love 804-827-2893
(176-10-31; 176-20-31)

The technical objectives are to: (1) Demonstrate the capability of remote sensors for detecting, mapping and tracking tropospheric pollution on urban to regional scales. (2) Evaluate the role of remote sensors in integrated monitoring systems. (3) Develop the capability for providing ground truth for eventual satellite measurements. (4) Develop a systematic approach for evaluating remote sensor candidates for future missions. The approach will be: (1) Aircraft tests of available remote sensor concepts in an urban environment in conjunction with user agencies. (2) Evaluation of remote sensor flight test data and correlation with in situ support data. (3) Systems requirement studies will be initiated to evaluate the eventual role of remote sensors in urban and regional monitoring systems.

W76-70466 **176-20-42**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING CONCEPTS FOR TROPOSPHERIC POLLUTION
C. L. Korb 301-982-6233
(176-20-31; 176-20-51)

The objective is to develop and evaluate an atmospheric pollution monitoring experiment which will provide the capability for measuring from aircraft and spacecraft the vertical pollution concentration profiles and near surface concentrations for a large number of tropospheric pollutants. The approach selected utilizes high spectra resolution and the variation of line profile with

pressure in the atmosphere to obtain pollutant vertical concentration profiles. The solar reflected infrared portion of the spectrum is used since the measurements in this region, unlike those in the thermal infrared, are sensitive to the effects of near surface pollutant concentrations. Also, the measurements are self contained since they are relatively independent of external environmental variables, such as surface temperature, and atmospheric lapse rate. Laboratory measurements will be made using a recently built breadboard unit, with synthetic pollutant atmospheres to validate the concept and evaluate possible experimental problems. An upgraded breadboard unit will be used to conduct field experiments and verify the concept of atmospheric concentration profiling. Analytical studies using a very high resolution atmospheric transmission program will be conducted for data interpretation purposes. High resolution laboratory measurements of the line strengths and widths of various pollutant bands will be made as required. Instrument optimization studies will be conducted and an aircraft instrument will be built and tested for the major tropospheric pollutants. These studies and measurements will provide a new technique, and the required instrumentation and analysis for remotely obtaining vertical concentration profiles for the major tropospheric pollutants. With these techniques recent analyses predict that fifteen important tropospheric pollutants can be measured with sensitivities which range from 0.0003 to 0.005 ppm.

W76-70467 **176-20-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TROPOSPHERIC POLLUTION SENSING
D. P. Burcham 213-354-3028

The general objectives are to develop and evaluate high spectral resolution remote sensor concepts for the measurement of tropospheric pollution, and to address current problems in tropospheric sensing with experimental studies. Specifically, the task covers: (1) Development and evaluation of both active and passive instruments which use infrared laser and heterodyne receiver technology. (2) Experimental pollutant measurements with the Mark 1 High Speed Interferometer (HSI), in a program which leads to a better understanding of urban air quality and to the definition of experiment requirements to make similar observations from airborne platforms in the future. The approach involves two areas of work. Improved infrared spectra will be obtained with laser sources and used to determine how well an airborne laser absorption spectrometer (LAS) will be able to produce altitude profiles of several important constituents (e.g. O3, H2O, NO, NO2). Ground-based laser instruments will be used to monitor ozone and nitric oxide over horizontal and vertical paths in the JPL ambient atmosphere, with emphasis on evaluating instrument sensitivity to various degrading factors. The Mark 1 HSI will be deployed in a number of preselected areas in the Los Angeles Basin at various times during the year which reflect typical meteorological conditions. In-situ measurements of atmospheric composition will be made near the ground over various path lengths and correlated with total vertical column abundances obtained from solar observations. The measurements will permit interpretation of the results in terms of spatial, diurnal, and seasonal variations in the air quality.

W76-70468 **176-30-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF LAKE PROCESSES, INCLUDING EUTROPHICATION AND WATER QUALITY
D. R. Chapman 415-965-5065
(176-13-11; 176-53-11)

The objective is the measurement and use of those characteristics of water pollutants and water quality indicators which are accessible by remote sensing in order to provide and demonstrate remote sensing techniques for the identification, quantification and mapping of water pollutants and their behavior as a means to understand those whole-lake processes necessary for monitoring and control and to characterize the eutrophic status of lakes. Techniques for the identification, quantification and mapping of suspended sediment, algae, other water pollutants and water quality indicators by remote sensors will be developed and documented. Laboratory and field measurements of the spectral characteristics of such pollutants will be developed into a library of spectral signatures using spectroradiometers and a rapid scanning spectrometer. Field measurements will be taken in conjunction with multispectral, narrow-band and color aerial photography, aerial spectrometry thermal linescanning, Landsat data and surface truth. Water bodies containing predominantly one type of pollutant will be examined to develop basic data on spectral signatures and thermal effects of the pollutant as well as for comparison with laboratory data. The relationships of spectral signatures to the photography and satellite data will be determined, including the averaging effects of broad bands. In addition, much of the same data will be used in the study of whole-lake processes involving the eutrophication of lakes such as lake circulations, circulation models, algal boom dynamics and lake eutrophication classification in a way acceptable to limnologists and other users.

W76-70469 **176-30-21**
Lewis Research Center, Cleveland, Ohio.
WATER/LAND POLLUTION MONITORING FEASIBILITY STUDIES
H. J. Mark 216-433-4000
(176-90-21)

The technical objectives are: (1) to detect, identify and monitor by remote sensing techniques, pollution due to strip mining of coal and other surface mining, and to determine the impact on the water quality of streams due to runoff from these mined areas, (2) continue development of remote sensing systems for monitoring water quality and limnological parameters in the Great Lakes. The approach will (1) continue present research on the spectral signatures of various soil types and demonstrate that multispectral sensing can detect and discriminate specific soil types. Develop a method to predict stream water quality changes due to runoff over these various soils. In cooperation with departments of the States of Ohio and Kentucky investigate the ability of remote sensing techniques to validate the system for application, (2) use existing data, such as ERTS, and additional aircraft overflights with multispectral sensors as required with ground truth to develop methodology for inferring water quality and limnological parameters. Continue to utilize cooperative arrangements with EPA, NOAA, and Canada for surface truth measurements in the Great Lakes area. Document techniques for transfer to user agencies.

W76-70470 **176-30-31**
Langley Research Center, Langley Station, Va.
COASTAL ZONE INVESTIGATION RELEVANT TO OCEAN DUMPING MONITORING
E. S. Love 804-827-2893

The objectives of this RTOP are: (1) to develop and evaluate remote sensing techniques for the detection and monitoring of substances and processes which affect water quality, (2) to develop analytical techniques including modeling which will permit more effective use of remote sensing data in water pollution monitoring and environmental assessment, and (3) to cooperate with user agencies in applying NASA technology to the monitoring of the water environment. Existing and new research will be extended through the focusing of the work toward applications using remotely sensed data to measure coastal zone parameters relevant to the monitoring of pollutants dumped into oceans. A joint plan will be developed and implemented with NOAA and other users to apply NASA technology to the monitoring of ocean pollution. The determination of spectral signatures of pollutants in water will continue with emphasis on the spectral signatures of special significance for ocean dumping. The development of pollutant transport and dispersion models for data interpretation and analysis will continue and measurements required for validation efforts in the New York Bight will be defined. Overflights will be performed with various existing sensors to evaluate their use in this specific monitoring task. Data analysis techniques will be extended to be as specific and quantitative as possible through the use of NOAA surface truth.

W76-70471 **176-30-41**
Goddard Space Flight Center, Greenbelt, Md.
NEARSHORE, RED TIDE AND ESTUARINE WATER CHARACTERISTICS

Warren A. Hovis 301-982-6465
(177-52-41)

The objective of this effort is to develop remote sensing techniques for use in detecting and identifying organic materials, such as red tide and pollutants, that occur naturally or are dumped into ocean waters; carry out supporting truth measurements, including development of new equipment and techniques; and to use thematic data to assess changes in estuarine water quality. Field investigations will be carried out combining ship and aircraft observations where in simultaneous surface truth measurements and remote sensing are carried out. Spectrometers and multi-spectral imaging radiometers will be flown on aircraft in selected coastal areas, such as the N.Y. Bight and the Gulf of Mexico, concurrent with surface measurements of such parameters as transmissivity, scattering and phytoplankton type and concentration. Comparison of the surface truth data with the remotely sensed data will be made to develop optimum data processing techniques for extraction of the desired parameters, e.g., type of red tide organism and concentration, type of pollutant and concentration, from the remotely sensed data. Spacecraft sensor data, LANDSAT in particular, will be used to evaluate changes in estuarine water quality and occurrence and coverage of red tides in coastal zones. These investigations will provide the basis for a remote sensing program to monitor red tide onset and growth, and pollution dumping and dispersion, by defining optimum spectral intervals and data processing methods to extract character and quantity information from remotely sensed data.

W76-70472 **176-30-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EPA/JPL LAKE CLASSIFICATION PROJECT
R. H. Green 213-354-6703
(141-95-01)

JPL and the Environmental Protection Agency (EPA), Corvallis, Oregon have conducted a feasibility program to utilize Earth Resources Technology Satellite (ERTS) Multispectral Scanner (MSS) data to examine fresh water lakes currently being studied by the EPA National Eutrophication Survey. Preliminary analysis of the results of this effort indicate that there is a high positive correlation between the spectral signature obtained by the ERTS MSS and water quality measurements and parameters gathered by EPA using ground observation methods. This proposed work will continue the effort and expand the development of lake classification procedures by machine methods. Additional emphasis will be given to the development of trophic index models through the combined use of EPA ground truth measures and ERTS MSS data. Utilization of EPA in-house expertise and JPL image processing and multispectral analysis capability will permit the development of cost-effective lake classification procedures. EPA will attempt to coordinate its water sampling program with projected future ERTS overpasses. Use will be made of existing spectrographic instruments for field checking of known water samples and/or lakes. Particular attention will be given to examining the spectral response of phosphorus, nitrogen, dissolved oxygen, chlorophyll and dissolved sediments in water. Attempts will be made to obtain ERTS/aircraft coverage simultaneously with the three projected sampling periods by EPA (spring, summer, fall).

W76-70473 **176-90-21**
Lewis Research Center, Cleveland, Ohio.
EPA/NASA GREAT LAKES BASIN PROGRAM
J. S. Fordyce 216-433-4000
(176-53-21; 644-02-02)

A joint agreement between EPA Region 5 and NASA Lewis is being developed which will respond to need which EPA has defined in connection with its responsibility for the Great Lakes Basin. The specific objective is for NASA to use its technology and capability to develop environmental monitoring systems for the Great Lakes Basin. The approach to be followed is a phased effort in close coordination with EPA Region 5 covering the development, test, feasibility demonstration and technology transfer of the followin-g monitoring systems: for water (1) remote sensing; (2) in-situ automated; (3) shipboard; for air (1) baseline/trend; and (2) ground based regulatory; and for land a remote system for non-point source runoff. In support to the above, a comprehensive effort on the development of data management and display systems and transport and dispersal models for Great Lakes application together with network strategy and communications will be undertaken.

W76-70474 **176-90-31**
Langley Research Center, Langley Station, Va.
COORDINATION AND PLANNING ACTIVITIES FOR THE ENVIRONMENTAL QUALITY PROGRAM
E. S. Love 804-827-2893

The purpose of this RTOP is to continue the Focal Center planning and coordinating activities for environmental quality; to explore with user agencies cooperative programs that will utilize NASA's expertise in the area of pollution monitoring; to conduct economic studies with emphasis on stratospheric research and future polluting monitoring missions; to establish updated list of measurement parameters to be used in support of advanced missions; to continue the existing agreement between NASA Langley and the Region 6 Virginia State Air Pollution Control Board; and to continue supporting Headquarters-OA with technical assistance involving preparation of material for the annual congressional testimony for the agency's Environmental Quality Programs, and preparation of material in support of New Start Programs. Additionally, Langley plans to prepare a tropospheric research plan which will essentially address the same questions as was covered in the Stratospheric Research Program plan approved by the Associate Administrator for Applications during FY-75. This RTOP is also intented to cover the extensive coordination activities required between this office and other Lead Centers, i.e., ERTS follow on evaluation, Aircraft Support requirements and participation in the many inter-agency working groups and committees (e.g.; ICMSE, ICMAREP, COSPAR, ICAS, ICCERSP) involved in Environmental Quality Programs.

Earth Resources Survey

W76-70475 **177-11-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SCANNER/CAMERA EVALUATION
D. P. Burcham 213-354-3028

Most digital imagery is acquired at lower resolution than is available from photographs taken under similar circumstances. The loss in resolution of spatial features is compensated for by an increase in spectral response; photographs monitor only visible and near-visible light but multi-spectral sensors are sensitive in reflective and thermal IR, and can be extended to microwave. Furthermore, digital imagery is in a convenient format for application of image enhancement and classification techniques, using a digital computer. These procedures have proven their utility at JPL and elsewhere over the past decade. The objective of this work is to evaluate the validity of human interpretation of high resolution black and white, color, and color-IR aerial photographs compared to computer-assisted interpretation of lower-resolution digital multi-spectral scanner imagery, including multi-spectral enhancement and image classification. Photographs and digital imagery of urban, agricultural, and geological test sites will be analyzed comparing the interpretations of the imagery to ground truth. The results of the study will be formulated as guidelines describing the circumstances for which photo-interpretation is the most cost-effective analytic tool, and those for which digital processing is required. Parameters limiting the utility of each technique will be identified, including those imposed by instrument design. Recommendations for modification of future instruments and processing techniques will be itemized in a comprehensive report.

W76-70476 **177-22-41**
Goddard Space Flight Center, Greenbelt, Md.
VISIBLE AND IR SENSOR SUBSYSTEMS
Harvey Ostrow 301-982-4107

High performance visible and IR sensor systems are required for future earth observation survey missions. Increased spatial and spectral resolution, improved signal-to-noise ratio, response

into the emissive IR and improved radiometric accuracy of the sensor systems are required. The tasks included in this RTOP will be used to achieve this improved sensor performance. Improved visible and IR detectors will be developed with special emphasis placed on self-scanned linear arrays. Included will be photodiode arrays, CCD arrays and hybrid structures in which HgCdTe elements are coupled to a silicon CCD in order to provide performance in the 10 micrometer spectral region. Other programs include: (1) development of solid state detectors with low noise preamplifiers to provide performance better than PMT's and (2) development of detector arrays that operate in the time-delay-and-integration mode to yield substantial improvements in signal-to-noise performance. To improve the radiometric accuracy of the sensors, better calibration techniques will be developed including very stable radiant sources as well as sources specially adapted for use with very large aperture sensors such as the thematic mapper. High performance scanning radiometers require accurate scan mechanisms with minimal jitter and high reliability. These will be developed in this program. The development of a laboratory to provide performance testing of earth observation sensors will be continued to permit in-orbit evaluation of system performance. Some of the critical technology required for advanced sensors that will be flown in future earth observation missions will result from the work performed in this RTOP.

W76-70477 **177-22-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
REMOTE SENSING OF SEA TEMPERATURE AND TURBIDITY
R. A. Bland 305-867-7705
(177-56-91; 177-70-91)

It is proposed to construct a laser system which will ultimately be employed as a remote sensor to obtain subsurface temperatures, turbidity profiles and other data in fresh and marine waters. These profiles will be obtained from the measurements of the shifted and unshifted wavelength radiation returns due to the Raman, Brillouin and Tyndall effects. Major components of this system will be obtained based on the results of a design study which will be completed December 1975. Initial laboratory experiments will be performed as the system is developed. Extensive testing of the laser system on a ship will be performed before the system is tested and operationally used in an aircraft.

W76-70478 **177-28-41**
Goddard Space Flight Center, Greenbelt, Md.
SIMULATION STUDIES FOR OPTIMIZATION OF THEMATIC MAPPER AND ADVANCED SENSORS
R. Jastrow 212-678-5619

The objective is to optimize the specifications of earth resource sensors in the visible and infrared regions by conducting simulation studies on the accuracy of terrain classification as a function of instrument performance parameters for the thematic mapper as well as more advanced sensors. Special emphasis is placed on spectral band-width, band placement, signal/noise ratio, electronic filter specifications, optical system, size and shape of IFOV, and sampling rate. Techniques and software have been developed to simulate satellite observations of earth resources for up to 24 spectral bands. Band width, band placement and various aspects of instrument response (see above) are specified for each study. The basic input to the simulation study consists of spectral signatures obtained by aircraft spectrometers for various crop types and soil conditions. Expected results are: (1) an evaluation of the effect of band size, band placement and instrument performance parameters on crop type discrimination, (2) the construction of a comprehensive library of spectral signatures for important agricultural crops at various stages of growth, soil and illumination conditions. Initially, spectra will cover the range 0.4 to 1.1 micron. The data base will ultimately extend to 15 micron.

W76-70479 **177-31-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IMAGE PROCESSING/LAND USE/HCMM
R. H. Green 213-354-6703

The objective of the project is to expand upon the Land Use Management Information System (LUMIS) application with special emphasis on (1) analyzing the suitability of using remotely sensed data and technology in the preparation of the LUMIS data base and using ERTS technology for updating the data base and (2) generating a transferrable LUMIS software package for use by other local and state government agencies. Tacoma, Washington has been selected as the initial city for transfer of this technology as specified in FY-75 RTOP 644-5X-XX. Using the FY-75 LUMIS as a starting point, the LUMIS application will be expanded in both scope and depth. Cost data on system development has been collected during FY-75. Similar data for system operation will also be collected and these costs will be used along with observation of actual L. A. City Planning Department utilization to define the technical specifications for generating a transferrable LUMIS software package. Furthermore, working in conjunction with L. A. City and the ASVT project definition FY-76 RTOP 177-6X-XX (Multiple Input Land Use System for Metropolitan/Regional Applications in California), this project will determine the extent to which remotely sensed data and technologies and digital image processing techniques can be utilized. A software requirements analysis plus an initial transferrable software package will be available by the end of FY-76. A more comprehensive package incorporating greater use of remote sensing technology is planned for FY-77.

W76-70480 **177-32-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW COST DATA ANALYSIS SYSTEM
D. P. Burcham 213-354-3028

The purpose of this task is to define advantages, disadvantages, availability, capabilities and other pertinent features of potential low cost data analysis equipment for small or medium size users to interface with their existing equipment or for stand alone data processing. The study will be restricted to processing data from imaging sensors and to the conversion of data from other sensors when necessary for relating to image data. Experience at JPL has shown that crucial factors in efficient image processing lie in on-line digital image acquistion, on-line volatile and hard copy display, and the image processing software system itself, thus these will be the primary areas to be studied. Because of the interrelation between software and hardware in image processing, consideration must be given to available image processing software and to tradeoffs between hardware and software processes. Thus, the recommendations for development of needed equipment and systems may include software. Since previous surveys have been aimed at the larger user, they must be reviewed for applicability to the small user. The data in these will be updated with new manufacturer's information, and the present state of the art will then be compared to that required for efficient image processing. Due consideration will be given to the possibilities of modular upgrades and standardized interfaces to keep user costs down.

W76-70481 **177-42-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
DATA TECHNIQUES FOR MINERAL EXPLORATION
D. P. Burcham 213-354-3028

The primary objective is to refine and improve image enhancement techniques developed by the JPL Image Processing Laboratory (IPL) and to apply these to geologic problems. In the past, these methods have proved to be extremely useful for the detection of hydrothermal alteration zones associated with possible mineral deposits, and for identification and mapping of geologic structures and lithologic units. Using a data base of spacecraft acquired multispectral digital data, computer processing with image analysis is necessary to extract that subset of information pertinent to solving a particular problem. Supplementary spectral data will be acquired using the previously developed backpack spectrometer, aircraft data, and laboratory analysis. Specific objectives will include the detection of prophyry copper deposits in southern Arizona and New Mexico in cooperation with Continental Oil Co., the detection of uranium sands in Wyoming in cooperation with the University of Wyoming, and the study of ultramafic rocks in southern Brazil in cooperation with the U.S.G.S. Further work will be undertaken in the field of lithologic identification and mapping. Areas of study will include southeast Alaska in cooperation with the U.S.G.S. and crystalline

terrain in New Mexico in cooperation with the University of New Mexico. Assistance will be provided to other investigators based on the applicability of their problems to developing or extending IPL enhancement techniques.

W76-70482 **177-42-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HIGH RESOLUTION ERS DATA TEXTURE ANALYSIS
D. P. Burcham 213-354-3028
(177-42-52)

The long term objective of this work is to demonstrate the utility of placing sensors capable of directly measuring ERS picture element texture on board future satellites. A family of texture measures will be delineated. Selection of the texture measures will be guided by effectiveness and ease of hardware implementation. High resolution images from sources such as Skylab or U-2 will be scanned and digitized. Texture will be measured for regions that correspond in size to one ERS picture element. In this manner we produce texture images that correspond to the standard MSS images. The texture images will supply additional dimensions to the four-dimensional MSS data. The effectiveness and utility of the texture measures will be demonstrated by segmenting the scene by the JPL MSS Bayesian classifier operating on texture images and four-channel MSS images.

W76-70483 **177-42-85**
Lyndon B. Johnson Space Center, Houston, Tex.
LARGE-AREA CROP PRODUCTION INVENTORY BY REMOTE SENSING
A. E. Potter 713-483-2071
(177-51-81; 177-52-82)

The expansion of crop production inventory technology from the relatively local areas over which it has been developed to the larger areas required for large area inventories using satellites, has uncovered a number of technical problems previously overlooked or underestimated. The objectives of the tasks outlined in this RTOP are to investigate solutions to problems associated with large area crop production inventory. The approach has been to separate the large-area crop production inventory process into a sequence of technical areas, and then to define the most important problems in each. Production estimates are based on the combination of yield and acreage information. An initial breakdown of tasks is made according to whether each relates to acreage, yield, or production. Within these areas, further subdivisions are made according to technical problems which need solution. Total crop acreage in large areas is estimated from computer-aided analysis of satellite multispectral imagery. The approach is first to determine crop acreage for a number of small sample areas chosen within the large area.

W76-70484 **177-43-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ERS SUB-PIXEL CLASSIFICATION AND SPECTRAL RESOLUTION STUDY
D. P. Burcham 213-354-3028

The objectives of this research is to demonstrate the utility of on-board classification of high resolution multispectral image data and to develop a quantitative relationship between the measurement element size (effective earth surface area implied by one image sample) and the spectral signature of the finest data element to be resolved. An ancillary objective is to propose suitable classification strategies and to study the data compression capability offered by the application of pattern recognition techniques to on-board data processing. High resolution images from sources such as Skylab or U-2 will be scanned and digitized at a family of sampling intervals. The high resolution images will be 'smeared' to produce an equivalent ERS MSS image. That is an image with approximately 100 square meter surface resolution. Smearing will be accomplished by averaging the number of high resolution image samples equal to one ERS image sample. The ERS equivalent images will be segmented either manually or by the JPL MSS classifier to define the class resolution provided by the data. The high resolution component images will also be segmented into classes and a histogram (relative frequency of occurrence) of classes will be generated. We will convert the histogram into a single feature for transmission and subsequent analysis. For example the class that corresponds to the peak in the histogram or the variance of the histogram (texture measure).

W76-70485 **177-44-31**
Langley Research Center, Langley Station, Va.
SENSOR EVALUATIONS
E. S. Love 804-827-2893

The objective is to determine the spectral bands which provide the characteristic signatures that relate remote sensor measurements to aquatic primary production. This effort will investigate the use of characteristic spectral signatures of the carotenoid pigments in phytoplankton to remotely determine quantitative characteristics of algae such as mass, productivity and growth rates. Initial studies will review available spectral data and an evaluation of the known relationships between carotenoid concentrations and the quantitative characteristics of interest. Subsequent work will include in-house laboratory studies of these relationships, development of multi-band recognition schemes, and laboratory tests of candidate sensor systems, with field tests of selected systems beginning in FY-77. Also included in this effort is correlation of eelgrass productivity with remote sensing techniques, originally using Kodak's special water penetration film and extensive surface truth measurements for synoptic coverage. In-house research will be augmented by a contract with Virginia Institute of Marine Science.

W76-70486 **177-44-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SENSOR EVALUATIONS
D. P. Burcham 213-354-3028
(645-30-08)

With the ready availability of the 24 channel multispectral scanner data and the Portable Field, Reflectance Spectrometer (PFRS), the problem of determining the most suitable bands and ratios for discriminating various geologic units and areas of hydrothermal alteration become exceptionally difficult by the techniques previously developed at JPL. Multivariate statistical analysis must therefore be used to analyze the 24 channel multi spectral scanner data to determine the optimal channels and ratios needed to distinguish various geologic units and recognize potential areas of economic importance. Such techniques include principal component analysis and discriminant analysis. Principal component analysis can be used to determine the interdependence of the various spectral channels and ratios for different geologic materials. Discriminant analysis enables the determination of the optimum combination of spectral bands which discriminate the spectra signature of one geologic unit from another. Ground-truth measurements on the spectral reflectivity of various materials obtained from laboratory analysis of field samples and in situ field measurements with the PFRS will be statistically compared to the 24 channel MSS data. The collected samples will also be analyzed to determine the minerals and chemical elements responsible for the material's spectral signature. A companion study will be the evaluation of the effect of sensor parameters on the ability to classify materials based on multivariate analysis.

W76-70487 **177-44-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SIMS EARTH OBSERVATIONS SRT
D. P. Burcham 213-354-3028
(645-30-02)

This RTOP combines a previous program 'Microwave Radiometric Measurements of Ice Thickness' (177-55-52), with a new program to provide supporting research for a Microwave Earth Observations experiment for the shuttle. Microwave radiometry has been proved a useful remote sensing tool for earth observations the NEMS and ESMR experiments on NIMBUS-5 and the S-193 and S-194 experiments on Skylab. These experiments have led to other microwave experiments developed for NIMBUS-F and now being developed for NIMBUS-G and TIROS-N. The shuttle, because of its extended capabilities over previous space transportation system offers a unique opportunity to significantly extend the developing applications of microwave radiometry. It can provide improved surface resolution

at frequencies which have been used on prior experiments, and provide for meaningful measurements at lower frequencies which have not been feasible for previous experiments. Measurements with improved resolution at longer wavelengths are especially useful for observing phenomena such as soil moisture permafrost regions, ice boundaries in lakes and oceans, etc. The shuttle imaging microwave system (SIMS), now in late definition phase will provide such measurements. This task will provide the supporting research required for interpreting the SIMS measurements in terms of geophysical parameters, which are of interest for hydrology, geology, routing, and other applications. The research will include theoretical modeling and controlled experiments using existing instrumentation (with minor modifications) previously developed as part of the ice thickness program.

W76-70488 **177-44-83**
Lyndon B. Johnson Space Center, Houston, Tex.
MULTIFREQUENCY MICROWAVE CLASSIFICATION OF SURFACE AND SUBSURFACE OBSERVABLES
Curtis C. Mason 713-483-6287
(177-51-84; 177-44-82)

Extraction of qualitative information on agricultural and soil properties has been demonstrated using data from microwave systems. This effort will extensively quantify the information available from the response of active and passive microwave sensors to a wide range of agricultural and soil hydrological phenomena associated with both surface and/or subsurface observables. The overall objective is to develop techniques by which (1) soil moisture profiles and (2) key agricultural crop phenomena can be accurately determined and/or differentiated by active and passive microwave sensors. The soil moisture investigations are a continuation of those being conducted within the joint soil moisture experiment using field and airborne microwave sensors. Field measurements of key crops (corn, wheat, soybeans, and milo) will be conducted by the University of Kansas using a radar spectrometer. These measurements will extend those previously conducted by the U of Ks, but will cover a more comprehensive range of phenomena over the complete growth cycle. The investigations will result in the definition of the microwave sensors response as a function of frequency, polarization, and incidence angle to (1) soil moisture profiles for different conditions including (a) crop cover, (b) surface roughness, (c) soil type, (d) underground anomalies, and (e) moisture state, (2) agricultural phenomena, including (a) crop type, (b)maturity, (c) plant turgidity, (d) foilage orientation, (e) foilage density, (f) foilage moisture, and (g) plant health. The results can then be used in the definition of optimal sensor type, frequencies, and operational conditions for use on shuttle and other spacecraft and aircraft applications. Data analysis techniques for optimal interpretation and utilization will be developed.

W76-70489 **177-51-41**
Goddard Space Flight Center, Greenbelt, Md.
JOINT MICROWAVE SOIL MOISTURE AGRICULTURAL EXPERIMENT
T. J. Schmugge 301-982-6360

The objective of this effort is to determine the capabilities of active and passive microwave techniques for use in the remote sensing of soil moisture. This involves the observation of changes in the emissivity or reflectivity for a soil as a function of moisture content. In addition, the possibility of using microwave techniques for detecting important parameters of a vegetative canopy such as amount and type of crop cover and degree of moisture stress is to be studied. The recent work under this RTOP has involved field measurements using truck-mounted microwave sensors for the determination of the emissive and scattering properties of surfaces and aircraft flights for the demonstration of the remote sensing capabilities of these sensors. It is proposed that these efforts be continued and that work be initiated on the development of models which can make use of this remotely sensed soil moisture data for the estimation of agricultural crop yields. Toward this end specific questions that must be answered include the depth to which the techniques can sense soil moisture variations, what amount of vegetative cover can be penetrated by the microwave radiation, and what information concerning the vegetative canopy can be obtained from the emissive and scattering properties of the crop itself. To accomplish these objectives a Joint Soil Moisture Experiment working group was formed in August 1973 consisting of personnel from Texas A&M University, University of Kansas, University of Arkansas, USDA-ARS (Chickasha, OK) and NASA (both JSC and GSFC). It is expected that the field and laboratory measurements will continue to be performed at these universities and this group will provide the manpower for performing the flight missions.

W76-70490 **177-51-42**
Goddard Space Flight Center, Greenbelt, Md.
CROP CLASSIFICATION USING TIME DERIVATIVES OF LANDSAT DATA
R. Jastrow 212-678-5619
(177-20-41)

The general objective of this program is to develop innovative techniques for extracting maximum-information from LANDSAT data with special emphasis on agricultural applications. Specific objectives are to (1) evaluate accuracy of crop classification and determine crop acreage using time-history techniques; (2) study signature-extension techniques, with objective of minimizing dependence of crop classification on ground-truth; (3) improve classification accuracies by correcting for atmospheric effects. Discrimination of wheat from other crop and plant canopies will be emphasized. A data-processing method has been developed by GISS working with Dartmouth and Columbia personnel to process LANDSAT data and other multispectral data on the basis of a profile of changes in spectral signature with time, i.e., time-history. The technique makes a pixel-by-pixel comparison of changes in spectral signature for up to four successive LANDSAT passes. An automatic discrimination is applied on the basis of time-derivatives of the spectral signature, represented as a vector in the four-dimensional space corresponding to the 4 MSS bands. Experiments to date involving this method, with only two ERTS passes and first time-derivative of the spectral signature have proven highly accurate in classification of wheat acreage. In FY-76, the project will be extended to more difficult crop-classification problems, using more ERTS passes and higher-order time derivatives. Further improvements in classification accuracy will be attempted by insertion of atmospheric corrections derived from detailed theoretical modelling of atmospheric absorption combined with high-spectral resolution airborne spectrometer data. Expected results are improved acreage and yield estimates at earlier times in the growth cycle, and minimization of the ground-truth required to make regionally valid crop production forecasts.

W76-70491 **177-51-81**
Lyndon B. Johnson Space Center, Houston, Tex.
FORESTRY APPLICATIONS PROJECT
A. W. Patterson 713-483-2204

The JSC Earth Observations Division and Southern Region, U.S. Forest Service began a cooperative effort in July 1971, to investigate the applications of remote sensing to Forestry. Two Forest Service employees were assigned to the Applications Office. Since then the Forestry Applications Project Team has determined that the following tasks should be developed into applications procedures-timber resource inventories, and soils resource inventories-using automatic processing and multispectral data. The over-all objective is to develop procedures for making forestry inventories utilizing remote sensing and implementing suitable techniques in the Southern Region. The approach to meet this objective will be through a thorough investigation and implementation of the following tasks (1) determine Forest Service requirements which can be accomplished by remote sensing techniques. (2) Establish task objectives and procedures for remote sensing studies involving certain requirements. (3) Perform the above tasks utilizing present state-of-the-art remote sensing technology, define areas of needed technological research and direct that research toward satisfying project objectives. (4) Evaluate the results of the investigations and assess their economic feasibility. (5) Verify techniques in a different forest ecosystem to determine breadth of application. (6) Transfer to the user agency the acceptable techniques and assist them in the implementation of the applications.

W76-70492 **177-51-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
THE APPLICATION OF REMOTE SENSING TO EVALUATING SURFACE TEMPERATURE DURING FREEZING CONDITIONS
P. D. Toft 305-867-7705
(177-70-91)

The primary objective of this investigation is to establish a cost-effective method using remote sensing to accurately determine the amount (temperature and duration) of crop freeze exposure over large geographical areas, and to develop a comprehensive cold weather climatology classification and geoatmospheric model of Florida's citrus areas for accurate freeze exposure forecasting. The approach selected utilizes airborne and satellite thermal data to measure the earth-air interface temperatures over selected agricultural areas during freeze conditions. The data are then used for comparison with actual freeze conditions and inputted into computer models. These models would then be improved as indicated by the comparison of the predicted vs. measured temperatures.

W76-70493 **177-52-21**
Lewis Research Center, Cleveland, Ohio.
SOIL, VEGETATION AND WATER IMPOUNDMENT STUDIES OF MIDWEST STRIP MINED AREAS
Mark Herman 216-433-3000

Various soil, water and vegetation parameters characteristic of both coal and clay strip mined areas will be used to classify selected mined areas as to their suitability for reclamation. In addition, current efforts as well as the effectiveness of earlier efforts for mined area reclamation will be evaluated.

W76-70494 **177-52-42**
Goddard Space Flight Center, Greenbelt, Md.
REGIONAL APPLICATIONS DEVELOPMENT
P. J. Cressy 301-982-2658
(644-01-41; 683-76-41)

The objective is to undertake projects involving joint participation of users and the Information Transfer Laboratory (INTRALAB) in the development of techniques for the application of remotely-sensed data to regional problems. Users will be invited to participate with INTRALAB in the analysis of user-identified problems of regional operational significance. Users will supply ground truth, and will assign personnel to work with INTRALAB, which will provide remotely sensed data (aircraft and spacecraft), discipline experts, and advanced facilities and information extraction techniques for image analysis. The intent will be to not only develop and transfer techniques for the user's specific problem, but also to thoroughly explore the utility of present remote sensing technology for the application under study. These studies will: (1) provide specific users with hands-on experience in applying remote sensing techniques to meet the user's operational objectives, and (2) establish a realistic basis for defining requirements for, and assessing potential benefits of, future earth applications missions.

W76-70495 **177-52-82**
Lyndon B. Johnson Space Center, Houston, Tex.
REGIONAL APPLICATIONS EXPLORATORY STUDY PROJECT
G. E. McKain 713-483-6287
(177-42-83)

Early in 1973, the JSC Earth Observations Divison and the State of Texas began a cooperative effort to investigate the utility of remotely sensed data as a source of land resources information. The specific objectives of the effort are: To establish, within the State of Texas, a capability to utilize remotely sensed data. To develop and transfer to Texas remote sensing technology which will support the operational needs of the State. To design and conduct pilot demonstrations of the application of remotely sensed data. To establish a mechanism within Texas for the implementation of a joint Texas/NASA demonstration project. The project is primarily a State activity within NASA making its major contribution in the following areas: (1) Orientation and training of State personnel to remote sensing technology. (2) Remote sensing systems design, technology development and technology transfer in support of State pilot demonstrations. (3) Providing remote sensing consultation in support of State programs. NASA's contributions in areas 1 and 3 will be accomplished by Project personnel; area 2 will be accomplished through NASA's supporting research and technology programs. The SR&T activity required to support the State's operational demonstrations will be mutually defined by Texas and NASA personnel.

W76-70496 **177-53-41**
Goddard Space Flight Center, Greenbelt, Md.
GEOLOGICAL INVESTIGATIONS USING LANDSAT AND RELATED DATA
Herbert Tiedemann 301-982-5123

The objectives are to continue evaluation of application of LANDSAT/EREP data to practical geologic problems in exploration for fossil fuels and geothermal energy sources, nuclear plant siting and environmental geology, and pursuit of increased computer and optical processing capabilities to identify, enhance and extract data relevant to solution of these problems. Current studies will be expanded to evaluate (1) linears mapping as a guide to subsurface structure in petroleum exploration and for regional tectonic assessment required for nuclear power plants siting, (2) use of color/tonal anomalies as guides to surface alteration effects related to petroleum or geothermal sources, and (3) potential for satellite data in production of environmental geology maps. Expanded capabilities in computer processes and optical techniques will be used to improve analysis of digital data and imagery. These studies will: (1) assess the capability of various data enhancement and extraction techniques available at GSFC to resolve energy- and environment-related geologic problems, and (2) identify limitations of present data and/or systems for use in addressing future requirements.

W76-70497 **177-54-11**
Ames Research Center, Moffett Field, Calif.
HYDROLOGIC MODELING
A. J. Stratton 415-965-5898
(177-64-11)

The objectives of this work are to: (1) develop inter-related management-oriented hydrological models, taking into account both supply and demand, that make optimal use of modern remote sensing capabilities; and (2) study the cost-effectiveness of such models as compared to the utility of conventional, presently used models or other management tools. Large water basins and regional water distribution systems, as typified by the California Water Project, will be the focus of study. Effort will be devoted to both the supply and demand aspects of such systems. The development of advanced applications techniques which provide methods of acquiring data inputs to supply and demand models will be pursued. As the remote sensing application techniques are developed, they will be made available for quasi-operational demonstration tests conducted jointly by NASA and user agencies under separate funding.

W76-70498 **177-54-12**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR SNOW AND ICE MAPPING AND MONITORING
W. I. Linlor 415-965-5538
(177-54-11; 177-64-11)

The objectives are snowpack measurements by use of remote sensor technology, to obtain hydrological cycle data input, so as to achieve better utilization of water resources, flood forecasting, hydroelectric energy production, and related activities. Remote sensing techniques will be applied for the measurement of the extent, depth, density, and percent moisture of snowpack, to assist in water resource management. Specific techniques include surface, airborne, and satellite-based instrumentation. Surface systems are needed for ground truth data. Time-progressive information will be obtained by completely automatic, remote installations to measure moisture in the snow by attenuation of microwaves between source and receivers that move vertically within dielectric tubes. Data would be relayed via satellite link. This is a joint project with the U. S. Forest Service and the U. S. Geological Survey. Airborne systems will

be investigated using passive and active electromagnetic measurements, the latter being based on multifrequency sounding to obtain snowpack depth, density, and moisture. Calculations will be continued for representative models snow, ice, water, and earth. Satellite-based systems will include passive microwave measurements to give synoptic, time-progressive surveys of snow coverage, water equivalent, and snowpack moisture (ripeness), in a joint project with the U. S. Geological Survey.

W76-70499 **177-54-22**
Lewis Research Center, Cleveland, Ohio.
SATELLITE ICE MONITORING FEASIBILITY STUDIES
H.J. Mark 216-433-4000

The objectives are to explore the use of remote sensing techniques for transportation applications in the oceans; to determine the feasibility of extending present techniques and capabilities that have been developed for Great Lakes ice shipping to shipping operations in Arctic areas including the use of satellite data to develop a transferable system for application to sea ice navigation. The approach is to use experience gained in developing a Great Lakes all-weather ice season navigation system, expand and extrapolate it, including the use of any applicable satellite data, to the needs of ocean shipping with emphasis on shipping operations in Arctic areas.

W76-70500 **177-54-41**
Goddard Space Flight Center, Greenbelt, Md.
MONITORING AND MODELING OF HYDROLOGIC SYSTEMS
A. Rango 301-982-5480

The thust of this effort is to; (1) characterize snowpack parameters with microwave measurements and digitally map snowcovered areas, (2) develop physically-based floodprone area signatures, (3) modify hydrologic models to make better use of remote sensing data, and (4) investigate new hydrologic modeling concepts that will make more optimum use of remote sensing capabilities. In order to measure more meaningful snowpack parameters satellite, aircraft, and field microwave measurements will be combined with detailed ground truth measurements. Semi-automatic mapping of snowcovered area for operational use will be accomplished using digital LANDSAT multispectral classifications. Multispectral signatures will be developed in areas known to be floodprone, and the signatures will then be transferred to other floodprone areas and any discrepancies will be field checked and the signatures refined. The currently existing capabilities of LANDSAT for measuring land use, surface water area, and imperviousness will be exploited to full potential by modifying existing hydrologic models so as to better accept the remote sensing inputs. Snowmelt subroutines will also be modified to accept the direct input of snowcover area, snowline elevation and albedo. New modeling concepts will also be tested in regard to compatibility with remote sensing. Streamflow simulations from models with and without remote sensing will be compared. It is expected that the microwave studies will for the first time allow high altutide estimates of snow depth and water equivalent. Combined with semi-automatic snowcover area extraction, the microwave data will provide results allowing recommendations for an operational snowpack monitoring remote sensing system. The development of floodplain signatures with physical explanations will permit operational agencies to make more objective use of remote sensing for floodprone area delineation and developmental monitoring. The results from the modeling effort will show the expected benefits of having up-to-date remote sensing information incorporated into streamflow simulations for water management.

W76-70501 **177-54-42**
Goddard Space Flight Center, Greenbelt, Md.
SEA ICE MONITORING
P. Gloersen 301-982-6362
(177-54-22)

The objective of this program is to determine the feasibility of an operational sea ice monitoring system for the purpose of providing increased safety for shipping operations in the Arctic sea lanes and for Arctic off-shore resource extraction, e.g., drilling platforms for off-shore oil. Effort will be directed towards a cooperative research program with USGS, CRREL, Bureau of Land Management, NSF, and NOAA in conjunction with their recently initiated Arctic Off-shore Program (AOP). These studies are also directed towards the definition of an ASVT for sea ice monitoring, which would involve the operational utilization of satellite data obtained from the NIMBUS-5, NIMBUS-6, NIMBUS-G and the SEASAT-A satellites. The cooperative research program will entail both the acquisition of data, its interpretation, and a cooperative planning of an operational ice warning system. Acquisition of data from aircraft platforms will involve utilization of USGS aircraft on a regular basis and NASA aircraft on an occasional basis. Instrumentation to be used to acquire sea ice data will involve active and passive microwave imagers, infrared imagers, and photography. In defining an operational system, the following possiblities will be considered: (1) the feasibility of transmitting, via APT mode, satellite information directly to ships and drilling platforms; and (2) relaying data acquired by surveying aircraft to such ships and drilling platforms by satellite relay in a fashion similar to the ice warn system developed for the Great Lakes. It is expected that this effort will result in the definition of a sea ice warning ASVT.

W76-70502 **177-55-31**
Langley Research Center, Langley Station, Va.
COASTAL PROCESSES
E. S. Love 804-827-2893

The objective is to investigate the ERS potential concerning coastal zone processes dealing with sedimentation (sediment transport, beach erosion, sediment quantification, etc.), current analysis, and water color. Research is to be oriented to take advantage of satellites such as SEASAT and NIMBUS in addition to ERTS. Emphasis will be on improvement of methods for quantification of sediment concentration, development of computer facilities and algorithms for the identification and quantification of multispectral scanner signatures of marine waters, and to investigate the potential of ERS in current analysis. Sediment: integration of the methodologies of leading authorities to develop understanding of remote sensing process of particulates followed by the development of strategies for quantification of sediment concentration; conduct additional aircraft flights with improved ground truth support; and initiate methods of evaluating dredge spoil plume dynamics and circulation patterns. Scanner signatures: adapt langley computer facility into advanced system specifically aimed toward identification and quantification of marine signatures; and expand capabilities for pretreatment of data and multiple regression techniques. The system development will include capability for accepting classification approaches from other organizations. Current analysis: existing ERS data will be examined to determine area and reflectance limits necessary to recieve current data from ERS; and feasibility of enhancing water current patterns with additives will be studied, and experimental observations of promising candidates will be made during aircraft and satellite overflights.

W76-70503 **177-61-42**
Goddard Space Flight Center, Greenbelt, Md.
DEFINITION OF WATER RESOURCES MANAGEMENT AND CONTROL ASVT
V. V. Salomonson 301-982-6481
(177-54-41)

The objective of this effort is to define a program that will involve the use and evaluation of products derived from spaceborne observing systems by agencies having mandated responsibilities for the management and control of water resources in the United States and selected regions. A particular objective is to define in detail the processing and distribution of remotely sensed-data as it proceeds from satellite observing systems to the point where it is used to make a decision or determination involving water resources or associated systems. This approach to be used will involve meeting and planning with user agencies representatives so that a project plan can be derived that will clearly meet real needs of the agencies involved and have their concurrence. Certain representative data products that the agencies can evaluate and approve will be produced. The process of producing these data products will be documented and feasibility established from these prototype exercises for the

conduct of a complete Water Resources Management and Control ASVT (WRMC-ASVT). The expected results from this effort will include: (1) selected data products representing those common outputs to be produced during a WRMC-ASVT; and (2) a project plan that meets the requirements outlined in Appendix A of the Office of Applications - Earth Resources Program Summary, January 1975.

W76-70504 **177-61-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MULTIPLE INPUT LAND USE SYSTEM FOR METROPOLITAN/REGIONAL APPLICATIONS IN CALIFORNIA
R. H. Green 213-354-6703
(177-52-51; 644-02-02; 656-11-03)

The objective of this ASVT definition project is the design and development of a land use information system to serve urban and regional applications. Major emphasis is to be placed upon: (1) technology development for construction of data base systems, (2) program design that assures that potential users in the State of California be able to interrogate/interface their own information systems with the data base, and (3) system design that accepts the full range of data sets of potential use to a variety of agencies operating in metropolitan regions. The data base design will incorporate the interfacing of tabular formatted geocoding systems already in existence with an on-going development of a raster scan formatted geocoding system. To insure that the overall system design is acceptable to user agencies, JPL's contacts with government agencies in southern California through the LUMIS project (RTOP 177-52-51) will be expanded by drawing in consultants from the University of California system (Riverside, Los Angeles, Santa Barbara, and Berkeley) to assist in project design and execution. The system will be developed with the close cooperation of the Southern California Association of Governments (SCAG). The program would encompass a five-year period incorporating progressively larger regions. The first year's effort will be devoted to determining system design criteria and user needs for the ASVT project. By the end of FY-77 software development and construction of a prototype geocoded information system of land use for metropolitan Los Angeles should be complete. During FY-78 and -79 data base sets will be constructed for urbanized and urban fringe areas in California and modeling and inventory applications will be conducted with user agencies. During FY-80 JPL will provide information to the State initiate a stand-alone land use information center.

W76-70505 **177-70-11**
Ames Research Center, Moffett Field, Calif.
WESTERN REGIONAL APPLICATIONS DEVELOPMENT
J. M. Deerwester 415-965-5897

The objective of this RTOP is to provide a focus for bringing to bear Center competence in remote sensing, data collection, and systems analysis on problems facing state and local agencies. Experiments will be performed to determine the contributions that remotely sensed data and other products of NASA technology can make to the statutory needs of the cooperating agency. These applications developments will make particular use of expertise in the fields of land use inventories, geology, hydrology and coastal processes. Wherever possible, the program will exploit Landsat data, including use of the Data Collection System. In general the approach will be to coordinate user needs directly with respective agencies within the eleven Western States (as defined by the Office of User Affairs). Emphasis will continue, however, on cooperative projects within the State of California. Workshops and seminars of general interest to regional users will be held, as appropriate, to apprise potential users of the applicability of aerospace technology to their needs. Those experimental projects that yield favorable results would be considered at a later date as candidates for more extensive applications demonstration projects.

W76-70506 **177-70-61**
Wallops Station, Wallops Island, Va.
MULTIDISCIPLINARY REGIONAL APPLICATIONS AND LAND USE
J. D. Oberholtzer 804-824-3411

The objective is to search for, define and demonstrate applications of remote sensing in cooperation with local, state, federal agencies and academic institutions. Regional applications that may be extrapolated to other areas will be emphasized. Particularly important are projects that impact coastal zone problems. Especially mans interaction with this zone as he seeks for example to manage wetlands, develop residential areas and industrial sites. The approach is to combine remote sensing techniques already developed and apply them to local problems along with a modest amount of development at Wallops Flight Center. Resources to be drawn upon include the ground truth instrumentation, aircraft, data center, analysis equipment, and the various support services available at WFC. Users include those WFC is already working with such as the Park Service and Agricultural Extension Services along with users still to be identified especially those connected with the Delmarva Advisory Council, a local group representing a wide range of economic activities in this region. Emphasis will be placed on projects which have application to the coastal zone.

W76-70507 **178-56-12**
Ames Research Center, Moffett Field, Calif.
ECOLOGICAL SCIENCES
H. P. Klein 415-965-5094

The objective is to apply NASA radio-telemetry, bio-instrumentation and remote sensing technology to the needs of wildlife resource management programs as defined by user agencies and the Congress. Demonstrate to user agencies how NASA technology can be used to gather critical data concerned with environmental vigor and degradation, wildlife resource and behavior patterns, and disease factors affecting domestic stock, human populations, and wildlife resources. The approach will be to match aerospace technology to the needs of user agencies for mapping and tracking of natural resources and animals. Coordinate these efforts through GSFC, JSC, and HQ in order to reduce redundancy and take advantage of best methods. ARC is responsible for coordinating the animal handling through the user agencies, developing animal collars, harnesses, and bio-instrumentation, and coordinating all NASA efforts toward goals responsive to the user agencies. GSFC will develop the instrumentation antennae and power supplies associated with long range telemetry. Use of aircraft and satellite imagery for detecting meteorological, sea ice, and vegetation changes will be studied to demonstrate its usefulness in combination with telemetry for wildlife resource management programs. The combined imagery and telemetry studies will be in conjunction with existing efforts of user agencies working on real-time wildlife resource management models. The user agency will take the responsibility for animal handling and much of the ground truth.

OFFICE OF SPACE SCIENCES

Launch Vehicle Development

W76-70508 **180-06-60**
National Aeronautics and Space Administration, Washington, D.C.
LAUNCH VEHICLE PLANNING STUDIES
B. C. Lam 202-755-3726

The objective of this task is to provide the studies and analyses required for OSS Launch Vehicle and Propulsion Programs planning, for OSS level space program planning, and for space shuttle user charge policy planning. Individual tasks are formulated and assigned by the Office of Space Science, by Launch Vehicle and Propulsion Programs, or by the Technical Planning Office, NASA/JSC. The contractor conducts studies and analyses (OSS planning studies, economic analyses, trade-off studies, investigations in areas of launch vehicle technology; etc.) that provide a base of technical information that can be drawn upon in the formulation of program recommendations.

W76-70509 **180-17-50**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEM PERFORMANCE AND TECHNOLOGY ASSESS-

MENT FOR UNMANNED MISSIONS
G. Wittenstein 205-453-3017

From previously developed studies and computer programs, new studies and programs will be developed which will evaluate system requirements in order to enhance accomplishment of unmanned missions. Special mission planning tools will be developed in conjunction with this. To accomplish this, the following tasks will be performed: (1) maintain and update methodology and computer programs, (2) provide evaluation of unmanned L/V and systems with respect to OSS mission accomplishment, (3) continue to analyze the Scout L/V performance reliability program, (4) perform mission planning and reliability assessment required for the various experiments, and (5) perform a special Mission Planning Computer System evaluation and feasibility study.

W76-70510 **180-17-54**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE COMPUTER TECHNOLOGY
J. B. White 205-453-3987

The coming decade of vigorous space activity by NASA and other organizations will require an increasingly reliable launch vehicle family. This includes the development of technology to provide flexible and reliable computation for future space missions. High performance data processing configurations with useful lifetimes up to five years for long duration earth orbital and planetary missions are being emphasized. Digital logic, circuits, packaging techniques, and configuration are being developed to meet the reliability and environmental constraints of these advanced missions. Emphasis is being given to continuation of research in modular computer configurations. Existing software is being refined and expanded and new software developed in the areas of failure detection, switching control, and recovery. The culmination of these developments and evaluations will result in the fabrication of a breadboard modular computer system which demonstrates and verifies the objectives, approach, and architecture of a long life fault tolerant computational system.

W76-70511 **180-17-55**
Marshall Space Flight Center, Huntsville, Ala.
CONTAMINATION CONTROL IN HYBRID MICROELECTRONIC MODULES
Salvadore V. Caruso 205-453-1505
(506-18-31)

The objective of this effort is to develop, test and evaluate processes, process controls, and electronic coating materials for protection of hybrid microelectronic circuit modules from contamination. In addition, detection methods for contamination inside packages will be developed and/or evaluated. Investigations will be performed to select and evaluate electronic passivation methods and materials and processes for application in particulate contamination control. Studies will also be performed in related areas such as wire bonding, package sealing and particle detection methods. To accomplish these objectives, a task in Hybrid Microelectronics Development Studies will be performed.

W76-70512 **180-31-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LIQUID PROPULSION TECHNOLOGY
P. J. Meeks 213-354-2546
(506-21-21)

The overall objective of this effort is to evolve and demonstrate the technologies of critical components for a 950 lb sub f thrust bimode propulsion system. Once these technologies have been demonstrated, they easily can be adapted to flight application by the ultimate user. The engine development effort, which consitutes a major portion of this RTOP, has as its objective the demonstration and evaluation of a preflight configuration bimodal rocket engine for unmanned planetary spacecraft applications. It will utilize the earth-storable propellants nitrogen tetroxide (N2O4) and hydrazine (N2H4), and will produce a bipropellant vacuum thrust of approximately 4275 N (950 lb sub f) at a 40:1 expansion area ratio. The Preflight model will be designed based on criteria sub p and information generated during prior years's efforts. This engine then will be subjected to performance, margin-limit, and life testing in a vacuum environment. System design and application analyses will be conducted to guide component design and development. These studies will be coordinate with potential early users to ensure that the resulting technologies will be applicable to proposed flight systems with minimal modifications.

W76-70513 **180-32-51**
Langley Research Center, Langley Station, Va.
SOLID ROCKET PROPULSION SYSTEMS
E. S. Love 804-827-2893

A review will be made of the criteria and methods of analysis used in the design, processes, and techniques used in the fabrication of solid fuel rocket motors, particularly those used in the Scout vehicle, and identify those areas where the design and/or process controls are inadequate. A development program will be conducted to determine the selection of an improved material to replace graphite materials currently used for nozzle throat inserts on solid propellant motors. A program will identify the critical design parameters that affect the reliability of pyrotechnic systems so that low cost, simple, and reliable systems can be used. An investigation shall determine what materials and designs are best for solid rocket motor nozzles including those used in new high energy propellant programs. Studies and demonstrations of high energy propellants in existing solid rocket motor hardware shall be initiated. A design feasibility study shall be conducted to delineate the mechanical and structural concepts and configurations for strapon boosters on small launch vehicles.

W76-70514 **180-72-50**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC EFFECTS RESULTING FROM EFFLUENTS PRODUCED DURING NASA UNMANNED ROCKET LAUNCHES
E. S. Love 804-827-2893

The objectives of this research are to examine the effluent from NASA unmanned launch operations which may alter the environment and to conduct a program to assess the possible impact of these operations on the environment. The type and amount of effluents from launch operations will be determined from studies of the launch systems. Analytical models are being developed and applied by the Marshall Space Flight Center to describe increases in concentration and dispersion of launch vehicle effluents. Measurements of the concentration and dispersion of effluents from selected launches will be made by the Langley Research Center. The analytical predictions and the experimental measurements will be used jointly to assess the effects of NASA unmanned launch operations on the environment. The primary environmental effects that will be determined are: (1) the spatial and temporal distribution of toxic materials in the vicinity of the launch site resulting from NASA unmanned launch operations; (2) possible adverse effects of exhaust effluents on vegetation and man in the vicinity of the launch sites, by studying the environmental fate of the effluents; and (3) the type and amount of material deposited in the troposphere during launch operations. This study is being coordinated with other related studies on the environmental impact of exhaust effluents through the NASA Panel on Shuttle Exhaust, OAST Shuttle Technologies Office. This work is also being coordinated with related DOD studies. Previously developed measuring techniques and hardware will be used whenever practical.

Planetary Exploration - Science

W76-70515 **185-47-51**
Goddard Space Flight Center, Greenbelt, Md.
ABSOLUTE PRESSURE, ATOMIC OXYGEN, AND ENERGETIC BEAM CALIBRATION FOR MASS SPECTROMETERS
H. B. Niemann 301-982-4706

The objective of this work is to develop new laboratory techniques and to construct facilities for testing and calibration of instruments to measure the neutral particle composition and temperature of planetary and cometary atmospheres. The

different atmospheric environments encountered in the various planetary and interplanetary missions as well as the different scientific goals set for the study of the planets require an extensive instrument and test facility development program which leads to a satisfactory laboratory capability for evaluation and calibration of flight instrument concepts and subsequently flight instruments. The different chemical properties of the various atmospheric constituents and the various gas dynamic conditions expected in a planetary entry or cometary encounter make it necessary to develop several separate systems each with a limited range of flexibility which together satisfy the test requirements. Static pressure calibration systems have been developed for calibration of mass spectrometers with non-reactive gases in the pressure range suitable for mass spectrometer operation, i.e., equal to or less than .001 mb. This technique has to be expanded to include pressure regions up to 100 bar, where instruments with extended dynamic ranges of greater than or equal to 10 to the 9th power can be calibrated for detection of minor constituents and the precise determination of isotope ratios. High speed computer compatible data recording is planned to improve measurement accuracy and data handling efficiency. Particle beam systems have been developed for chemically active gases, i.e. O and H. These particle beam techniques need to be expanded to increase the kinetic energy of the beam particles from is less than or equal to 0.5eV to greater than or equal to 10eV for better simulation of actual flight conditions. The effect on the instrument performance of high velocity impact on instrument surfaces by complex molecules will be evaluated specifically for cometary missions.

W76-70516 **185-47-52**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT FOR NEUTRAL GAS COMPOSITION MEASUREMENT IN PLANETARY AND COMENTARY ATMOSPHERES
H. B. Niemann 301-982-4706

This research plan is concerned with the overall improvement of neutral gas composition measurements planned for the atmospheres of the planets and comets. In general, improvements are sought in two basic areas; (1) sensor concept and application, and (2) optimization of basic instrument parameters in anticipation of restrictive mission constraints. In the first area, sensor development will be directed toward: (1) the improvement of ambient gas sampling techniques for high velocity probes into high density atmospheres (e.g., Saturn or Uranus entry probes), (2) the design of more efficient ion sources of both the open type which provides side-energy focussing, and the closed type which increases the thermalization of the gas being measured, and (3) development of a neutral particle reparticle retarding potential analyzer for high velocity probes. In the second area, neutral spectrometer system development will be directed toward optimizing existing techniques in view of rigorous requirements anticipated in forthcoming planetary and cometary flight opportunities. This work will concentrate on: (1) development of smaller, lighter, higher resolution, less expensive mass analyzers, (2) improvement of ion current detectors applicable to digital systems, emphasizing accuracy, sensitivity, and stability, and (3) development of improved digital logic and on-board data processing sub-systems. Periodic earth atmosphere flight tests will be performed to evaluate developments in the ion source area and in the on-board data processing system under true flight conditions.

W76-70517 **185-47-53**
Goddard Space Flight Center, Greenbelt, Md.
ION MASS SPECTROMETER TECHNIQUES FOR PLANETARY AND COMETARY EXPERIMENTS
H. A. Taylor, Jr. 301-982-6610

The purpose of this RTOP is to support instrument development for optimizing the direct measurement techniques used in the detection of ambient thermal ion composition and concentration from planetary probes, orbiters, and cometary probes. The desirability for optimizing the Bennett RF Ion Mass Spectrometer measurement technique is brought about by the mission constraints anticipated for future flight opportunities which demand automatic inflight adaptability in response to limitations in telemetry rate, power, and weight. New missions present additional challenges in the measurement technique, in the form of the effects on sampling of high spacecraft velocity. Realization of these objectives in the midst of a constantly evolving technological development in turn requires a continuing evolution of instrument concepts. To respond to these requirements, improvements in the Bennett spectrometer instrument are planned in three areas: (1) adaptive step-dwell ion peak detection, optimized according to spectral range and peak spacing, (2) access and repeats of randomly selected prominent peaks identified in exploratory scans, replacing the present requirement for serial selection, and (3) implementation of a triple-beam ion source-test facility, including individually variable energy and density, permitting a more rigorous calibration of the servo Va-Vs ion sampling technique. These tasks involve electrical design modifications and testing, emphasizing a controlled and reliable extension of present technology. It is planned that these improvements will be evaluated when possible as part of earth flight tests involving cooperative participation as a piggy-back instrument on as-available rocket payloads.

W76-70518 **185-47-54**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED EXPERIMENT DEVELOPMENT FOR PARTICLE COMPOSITION MEASUREMENT IN PLANETARY ATMOSPHERES
H. B. Niemann 301-982-4706

The objective of this work is to develop a practical technique for the determination of the composition of the gas and the cloud particles in the lower atmosphere of Venus and the outer planets. The method of mass spectrometry for the composition determination of solid materials and condensibles will be adopted for space flight application. Several different atmosphere sampling techniques will be developed and studied for optimum efficiency in the specific application of the various principle atmospheres. Sampling techniques employed in the high temperature CO2 environment in the lower atmosphere of Venus differ significantly from those employed in the relatively cool H2/He environment in the lower atmospheres of Saturn or Uranus. The analysis of solid particles deserves special attention as it requires a much higher degree of instrument complexity than required for atmospheric gas analysis. Laboratory proven techniques will be adopted for flight application when practical and new sampling concepts will be developed when required.

W76-70519 **185-47-55**
Goddard Space Flight Center, Greenbelt, Md.
SPECTROSCOPY AND PHOTOCHEMISTRY OF PLANETARY AND COMETARY MOLECULES
L. J. Stief 301-982-2529

The objectives of this program are to measure the optical and chemical properties of atoms and molecules which are important in understanding the composition of planetary atmospheres and comets. Emphasis is placed on those problems which are of immediate concern for interpreting the results of rocket and satellite observations. In these investigations the well known techniques of optical spectroscopy and of photochemistry are applied under well defined experimental conditions. Sophisticated techniques have been developed for data reduction and for handling the small signal levels which are usually encountered. The flash photolysis-resonance fluorescence apparatus is now equipped with a variable temperature cell and the entire experiment is linked to the IBM/1800 computer for realtime data reduction and analysis. Time resolved detection of the atomic species H, O, and S has been achieved via resonance fluorescence and/or resonance absorption. The apparatus is being used to measure relative probability of primary photodissociation channels and to measure absolute rate constants as a function of temperature for atom-molecule reactions. Measurements on photodissociative excitation of CO2 have been extended to include cross sections for producing CO (a cubed pi), CO2(+)(A squared pi), and wavelength sub u and a function of incident photon energy. Excitation cross section for electron impact on CH4, NH3, and H2O have been measured for those spectral features which lie between 1100 and 2000A. The electron excitation apparatus was modified and results have been obtained for

electron impact on N2 and O2 to produce emission in the EUV is less than A.

W76-70520 **185-47-56**
Goddard Space Flight Center, Greenbelt, Md.
NEGATIVE IONS IN PLANETARY ATMOSPHERES
A. C. Aikin 301-982-4913

The objective is to determine the altitude distribution and species of negative ions present in planetary atmospheres such as Venus and Mars. Since negative ion formation and species will depend on the presence of minor neutral atmospheric constituents such as molecular oxygen and water vapor, identification of negative ions can be used as a tracer of these neutral constituents. The present study will simulate the lower ionosphere on a CO2 atmosphere with trace neutral constituents and identify species of negative ions. A negative ion detection system for sampling in planetary atmospheres will also be developed. This system will initially be utilized for the earth's atmosphere. The research has application to the manned and unmanned exploration of the Martian surface, since it defines the electrical environment in which systems operate. It has application to meteorology in that negative ions found can be utilized as tracers to determine factors involved in large scale circulation and interaction between different atmospheric regions. Development of an instrument suitable for a Viking type Mars mission is a prime objective.

W76-70521 **185-47-57**
Goddard Space Flight Center, Greenbelt, Md.
PLANETARY ATMOSPHERIC DYNAMICS
J. A. Pirraglia 301-982-4528

Recent planetary missions have greatly increased our knowledge of the atmospheres of Jupiter, Venus and especially Mars, and future missions promise further results. For a full understanding, it is necessary to develop a general approach to theoretical atmospheric dynamics based on the existing temperature structure and cloud formation data obtained from planetary missions. The analytical techniques developed will be used in the interpretation of existing data and in the improvement of models which are necessary to consolidate the measured quantities into a comprehensive view of the solar system. The planets present contrasts in mass, rotation rates, radiative time constants, heat deposition and topographic influence of the atmosphere. These widely differing conditions permit the isolation of specific dynamic phenomena and allow comparison of different regions of the parameter space associated with a particular phenomenon. Our increasing knowledge of these disparate atmospheres when augmented by analytical models will lead to a greater understanding of the dynamics of our own atmosphere.

W76-70522 **185-47-66**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC CHEMICAL PHYSICS - RESEARCH STUDIES OF PROCESSES IN PLANETARY ATMOSPHERES, COMETS AND INTERSTELLAR SPACE
D. R. Chapman 415-965-5065

The objective is to determine products, rates, and yields of energy transfer reactions in planetary atmospheres, comets, and interstellar space. Solar and galactic radiations interact with the atmospheric constituents to produce excited and ionized species and free radicals, which then react to form other ionized and excited species, and/or neutral unexcited species, and/or reradiate spectral energy. Insight into the nature of planetary atmospheres, comets, and interstellar matter can be obtained from studies of these processes under controlled laboratory conditions. The recombination of CO and O to produce CO2 will be investigated under conditions simulating the CO2-rich atmospheres of Mars and Venus. This study will consider the effectiveness of minor constituents such as CL, S, and OH in catalyzing the recombination reactions. This latter study is particularly relevant to the CO2 photochemistry on Venus; The ultraviolet photolysis of CH4, NH3, H2O and H2 will be investigated and the quantum yields and fluorescence emission cross-sections determined. These studies will contribute to our understanding of the photochemistry of reduced atmospheres (e.g. Jupiter) and will provide scientific support for future planetary exploration.

W76-70523 **185-47-67**
Ames Research Center, Moffett Field, Calif.
STRUCTURE OF PLANETARY ATMOSPHERES
D. R. Chapman 415-965-5065
(384-47-66)

The basic goal is to connect atmospheric observations with theory. Immediate objectives are: (1) structure of the ionospheres of Venus, Mars, Jupiter, and other planets, and the moons of Jupiter and Saturn; (2) interactions of planetary ionospheres with the solar wind; (3) dynamics of the atmospheres of Venus and Mars; (4) atmospheric structure of the Jovian planets and Titan; and (5) mean particle sizes and optical depth of Saturn's rings. All of this work is closely related to recent spacecraft missions, to programmed missions such as Venus Pioneer, or to missions in the study stage such as those to the outer planets. The abundances and distributions of ions, electrons, and minor constituents on Mars, Venus, the outer planets, and the moons of Jupiter and Saturn are being studied theoretically, using data from observations and laboratory measurements. In each case this work involves numerical solution of appropriate conservation equations. For example, in the case of Io we solved the complete set of coupled mass, momentum, and energy conservation equations for electrons, ions, and neutral particles. Thermal structure models have been constructed to understand the operation of the greenhouse effect on Titan. In order to understand the dynamics of Venus' atmosphere, calculations are being carried out to examine the effects of rotation, apparent solar motion, and the energy deposition profile on the circulation of the atmosphere. The Mintz-Arakawa model of the earth's atmosphere is being adapted to the conditions on Mars to permit a calculation of the general circulation of the Martian atmosphere. Estimates of the particle size in the rings of Saturn are obtained from analysis of IR and microwave measurements.

W76-70524 **185-47-68**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERES - STRUCTURE AND COMPOSITION
Alvin Seiff 415-965-5685
(185-47-69; 185-47-67)

The ongoing OSS program to explore the planets includes two missions, Viking and Pioneer Venus, on which properties of the planetary atmospheres will be measured during entry and descent to the surface by instruments carried by the probes. These experiments have grown out of research supported by this RTOP. The continuing studies will optimize the approach and maximize the return related to atmosphere structure from the Viking Entry Science experiment, and will further develop the capabilities of the Pioneer Venus experiment. A major thrust of this work recently has been the relationship of measured parameters to the winds at the entry sites and the overall circulation of the planets' atmospheres. The further development of wind observational techniques will require continuing effort. Extension of experiment capabilities in several directions is also to be pursued. These include turbulence measurement, and its relationship to turbulent mixing and transport in the atmosphere; precise definition of molecular weight of hydrogen-helium atmospheres, as a means for defining the hydrogen-helium ratio; and definition of the probe mass loss as a function of time, to permit the experiments to be performed with precision on entries into the giant outer planets which are accompanied by large mass loss of the heat shield. In addition, some work will be devoted to study of composition experiments for missions to Saturn, Uranus, and Jupiter.

W76-70525 **185-47-69**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERES EXPERIMENT DEVELOPMENT
D. R. Chapman 415-965-5065

The objective of this program is to establish the feasibility of experimentally identifying the composition of planetary atmospheres by utilizing the spectral signature of atmospheric components as measured with attenuated total reflection techniques (ATR) on atmospheric probes. ATR techniques should be especially effective for monitoring the proposed organic and

inorganic constituents of the atmospheres of Jupiter and Venus without the necessity of sample ingestion or erection of experimental components external to an atmospheric probe. The ATR technique will be applied to the measurement of the spectral characteristics of thin films of typical proposed constituents condensed onto the outside of simulated windows of an atmospheric probe. Commercially available apparatus will be employed to obtain the pertinent signatures, applying minor hardware modifications necessary for the particular requirements of the pertinent atmospheric constituents. The possibility of identifying several constituents from a layer of one constituent deposited on a sub-layer of another constituent, as well as single layers of mixtures of two or more constituents, will be investigated. Based on the results of the measurements, consideration will be given to the feasibility of incorporating a typical ATR apparatus into a space experiment by considering component development requirements.

W76-70526 **185-47-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATMOSPHERIC EXPERIMENT DEVELOPMENT
D. P. Burcham 213-354-3028

This work defines, develops and evaluates new or improved science experiments for the exploration and study of the atmospheres of solar system bodies from spacecraft. The approach is through research in the following categories: (1) development and application of practical radiative transfer theory applicable to remote sensing experiments; (2) interpretation and critical analysis of existing data from planetary missions and Earth-based observations; (3) laboratory and theoretical studies of physical and spectral properties of atmospheric gas and cloud constituents relevant to specific experiment goals; and (4) participation in planning mission science by evaluating feasibility of key objectives using realistic technology within a framework of spacecraft and mission constraints. Instruments and techniques are developed via detailed numerical studies and error analyses and laboratory, ground based or airborne experiments as appropriate. Atmospheric models are developed and continually refined to maximize the realism and relevance of numerical work. Experimental techniques developed under this task are being implemented on Viking, MJS and Pioneer Venus. Innovative approaches to the analysis of infrared radiometric data originated under this task have been applied a posteriori to Mariner 10 and Pioneer 10/11 data to make important dicoveries about Venus and Jupiter. New and continuing work for FY 76 centers on (1) remote sensing of Uranus and Neptune, (2) direct measurement of the H2/He ratio in outer planet atmosphere, (3) advanced Jovian temperature sounding experiment, (4) experimental methods for the structure and composition of cloudy atmospheres, especially Venus; and (5) development of ion sources for entry probe mass spectrometers.

W76-70527 **185-47-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THEORETICAL STUDIES - PLANETARY ATMOSPHERES
D. P. Burcham 213-354-3028

A board program of applied and theoretical studies related to planetary atmospheres will be conducted, with the following primary objectives: (1) understanding the properties and determination of the parameters of planetary atmospheres, (2) application of laboratory experimental data to the understanding and interpretation of spectral features and mechanisms for complex planetary atmospheres, (3) applying these findings toward design of ground based and spacecraft experiments, and (4) interpretation of above data as well as other observations to aid in the evolution of valid planetary atmospheric models. This program contributes to NASA planetary missions both in its direct research relevance to planetary atmospheric science and in the maintenance within JPL of a staff of specialists who may evaluate and define scientific objectives and experiments for planetary flight projects. The studies to be conducted in FY 76 pertain to planetary atmospheric modeling, radiative transport theory and theoretical spectroscopic development for studies of planetary atmospheres.

W76-70528 **185-47-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IONIZATION AND RATE PROCESSES IN PLANETARY ATMOSPHERES
D. P. Burcham 213-354-3028

The objective is to apply the unique and complementary laboratory instrumentation at JPL towards a dedicated study of ionic processes and chemical synthesis in planetary atmospheres. Some specific objectives for the coming fiscal year include: (1) determine the rate constant for the three-body reaction of CH3(+) ions with H2 and other three-body reactions of importance at Jupiter, (2) studies of the reaction of H atoms and other radicals with ions, (3) laboratory work on the upper atmospheric chemistry of the satellites of the Outer Planets, (4) modeling of the upper atmospheric chemistry of Jupiter including effects of metal ions and of energetic particle precipitation via the Io-ian flux tube. Using a new calibration procedure developed in our laboratory, absolute elastic and inelastic, differential and integral, cross sections of a electron-molecule (or atom) collision processes which occur in planetary atmospheres are measured, and the methods of electron-impact spectroscopy are used to locate and identify low-lying optically forbidden transitions in CO2, H2O, NH3, CH4, H2S, and HCN. Elastic, inelastic, and superelastic cross sections from radical atomic species, and metastable molecular states [O, O2 (2 super 1 delta g)] are also measured.

W76-70529 **185-47-91**
Langley Research Center, Langley Station, Va.
PLANETARY ATMOSPHERIC PROCESSES AND MEASUREMENTS
E. S. Love 804-827-2893
(384-47-91)

Properties and processes of the earth's upper atmosphere, as well as the atmospheres of other planets, will be studied using ground-based and satellite measurements, laboratory simulations, and theoretical studies. Earth aeronomical measurements employing various techniques are compared with drag measurements of the NASA Langley Air Density Explorer satellites to obtain a more comprehensive picture of our thermosphere and exosphere. The vertical distribution of ozone in our atmosphere is determined spectrophotometrically from ground-based measurements of satellites passing into the Earth's shadow. Photochemical models of ozone are formulated. Theoretical and experimental studies of gas-surface interactions are performed. A number of studies concerning atmospheric processes and measurements apply to other planetary atmospheres. Studies of the meteorology of Mars, Venus, and other planets are being employed to evaluate and improve instruments and measurement techniques on other planets. A unique molecular beam mass spectrometer system is being developed to study reactive and nonreactive gases in planetary atmospheres. Theoretical studies are being performed on the composition, density, temperature, and evolution of the thermospheres and exospheres of Mars, Venus, and other planets and planetary satellites. Improved techniques are being developed to analyze radio tracking data, solar occultation data, and other data types to determine characteristics of planetary atmospheres. Design studies and formulation of design criteria for possible instruments, measurement techniques, and spacecraft to further our understanding of planetary atmospheric processes will be continued.

W76-70530 **185-47-92**
Langley Research Center, Langley Station, Va.
MAGNETOSPHERIC PHYSICS
E. S. Love 804-827-2893

The overall objective of this work is to accurately measure the constituent number density of the terrestrial thermosphere (100 to 300 km). The approach centers on the development of a unique molecular beam mass spectrometer system which virtually eliminates gas-surface interactions and makes possible the accurate measurement of reactive gases such as atomic oxygen. The feasibility of this instrument design for measurement of reactive gases in the atmosphere has been demonstrated by theoretical and experimental work. This work has included design and tests of engineering models of the primary instrument components such as the ion source, mass separator, and ion collector system. Studies of vehicle requirements for flight measurements with this instrument have also been initiated and

these preliminary studies indicate that all vehicle requirements can be met by using the third stage of the Scout vehicle or the second of a Delta vehicle with only modest modifications.

W76-70531 **185-47-94**
Wallops Station, Wallops Island, Va.
EXPERIMENTAL AND THEORETICAL STUDIES OF PLANETARY ATMOSPHERES
A. C. Holland 804-824-3411

The objective of this RTOP is to carry out an integrated experimental and theoretical study aimed at improving our understanding of the optical properties of planetary atmospheres including the effect of aerosols on slant path visibility through the atmosphere. Special emphasis will be placed on (1) developing and improving model atmospheres for use in remote sensing, (2) development of instrumentation for measuring optical parameters of the atmospheres, (3) improving existing theoretical models of radiative transfer through the atmospheres containing significant amounts of particulate matter (i.e. haze, dust, ice crystals, fog droplets).

W76-70532 **185-50-40**
Marshall Space Flight Center, Huntsville, Ala.
PLANETARY X-RAY DIFFRACTOMETER
Thomas A. Parnell 205-453-5130

An X-ray diffractiometer will have high priority on any planetary landing mission. Constraints imposed by the environment will restrict the range and power of techniques which may be applied, and consequently the value of the mineralogical information carried in diffractograms produced. In order to obtain the most powerful instrument, some unusual techniques of diffractometry need be examined. The specific objective of this program is to analyze quantitatively the performance of multielement proportional counter arrays used in diffractometry and to test the results with a laboratory model of such a counter. This RTOP consists of a single task. Design studies will be made for a multielement proportional counter diffractometer capable of good resolution at most Bragg angles, yet with adequate speed of analysis, low power consumption, low weight, high detector signal-to-noise ratio, and long lifetime. Mathematical analysis will be performed to determine the optimum extent, type, and geometry of such a multi-element proportional counter array. A model will be built and used to produce diffraction patterns of minerals. Multilayer proportional counters will be used to determine the extent to which the nuclear generator and cosmic ray background can be reduced.

W76-70533 **185-50-51**
Langley Research Center, Langley Station, Va.
REMOTE DETECTION OF SURFACE PROPERTIES OF PLANETS
E. S. Love 804-827-2893

The objective of this research is the determination of planetary surface properties such as particle size, interparticle separation, albedo, composition, dielectric constant, and surface roughness from analyses of the characteristics of radar signals and solar radiation that have been reflected from planets and are detected by planetary orbiters or Earth-based instruments. The research is divided into three parts: (1) a theoretical part, that includes rigorous derivations of photometric functions that describe reflected radiation in terms of scattering geometries and surface properties, quantitative treatments of polarization phenomena, studies of the photometric effects of rough topographies, and the development of a comprehensive mathematical formalism for accurate interpretations of radar-backscatter data from small planetary areas; (2) an experimental part, that includes brightness measurements of laboratory soil samples for the purpose of verifying, refining, and supplementing the theoretical formulae; (3) an applications part, that includes the interpretation (by means of the theoretical expressions) of existing and future photometric, polarimetric, and radar data on Mars and possibly other planets.

W76-70534 **185-50-60**
Ames Research Center, Moffett Field, Calif.
PLANETOLOGY GEOMORPHOLOGY AND SURFACE PROCESSES OF PLANETARY BODIES
D. R. Chapman 415-965-5065
(384-50-71)

The objectives are to (1) study the relative expressions of the impact process on the production of surface features of inner planets and their satellites, (2) determine parameters governing eolian processes in the Martian environment and use this information to perform wind tunnel experiments, and (3) determine feasibility of making lead age determinations on planetary surfaces using a miniaturized ion probe. The approach is to (1) characterize morphology and size frequency distributions on recognized mercurian surface units and use these data with other inputs to reconstruct the impact history and to evaluate plains forming mechanisms. (2) carry out a statistical analysis involving all Martian craters with diameters larger than 3 km that will include all parameters necessary to evaluate the style of cratering on Mars as compared to the Moon and Mercury. (3) Conduct experiments using the Martian Surface Wind Tunnel to study threshold, and in other studies, assess the effect of crater geometry on eolian patterns and study the paths of wind driven grains resulting from crater controlled wind patterns using computer models.

W76-70535 **185-50-61**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF PLANETARY BODIES
D. R. Chapman 415-965-5065

The objectives are to obtain a better understanding of selected problems pertaining to planetary surface phenomena, the composition, structure and evolution of planetary bodies and their satellites, and the origin of the solar system by means of theoretical investigations employing the results of spacecraft and ground-based experiments. Theoretical knowledge, physical insight, and mathematical modeling techniques are used, together with astronomical and geological data, to construct self-consistent mathematical descriptions of planetary processes and structure. Analysis and interpretation of the results of these model calculations are applied to such topics as: the evolution of Jupiter, wind-blown surface features on Mars, and the calculation of conditions within the early solar system.

W76-70536 **185-50-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY STUDIES
D. P. Burcham 213-354-3028

We are prepared to measure the near IR (1-5 micron) reflectance of various ices and from the spectra, determine the complex refractive indices of these ices. The ices may exist either as pure phases, mixtures, hydrates, clathrates, compounds or as altered compounds (by UV irradiation or proton bombardment). With our present system, we will be able to study all but the altered compounds. The fundamental physical constants measured in this program may be used for scattering calculations in any theoretical model of atmospheric or cloud radiative transfer or surface reflectance.

W76-70537 **185-50-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETOLOGY INSTRUMENT DEVELOPMENT
D. P. Burcham 213-354-3028

The goal of this work is the development of six spacecraft-borne experiments which should be particularly effective in the study of planetary surfaces. Extension beyond present capability for the exploration of Mars is the principal objective in each case, and these specific experiments were selected on their potential for shedding new light on significant questions regarding that planet. However, there also exist potentially important applications for these instruments on other planetary missions. The six instruments/experiments are: (1) X-Ray diffractometer/spectrometer, (2) differential scanning calorimeter, (3) area array camera using DDC sensors, (4) orbiting gamma-ray spectrometer, (5) Alpha/X-ray analyzer using solid state detectors, and (6) dielectric constant/loss tangent of CO2 ice by radar. A complementary camera development activity to the linear array camera described is covered in an Advanced Technical Development (Code 186) RTOP; sesnor development is being supported by an OAST task.

Planetary Exploration Advanced Technological Development

W76-70538 **186-68-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IMAGING SYSTEM TECHNOLOGY FOR PLANETARY MISSIONS
R. R. McDonald 213-354-6186
(185-50-73; 506-18-11)

The objective of this program is the development of imaging instrument technology using line and area array CCD (Charge Coupled Device) sensors. Expected advantages of cameras using these sensors, compared to current Mariner technology, are extended red and near-IR response, increased sensitivity and dynamic range, lower cost, lower instrument weight, decreased power, and a simpler interface adaptable to different types of spacecraft. The camera development will be coordinated with development of CCD sensors, with the initial objective of developing a medium-resolution area array camera for use on the proposed Mariner Jupiter/Uranus 1979 (MJU'79) Mission. Future development efforts will be directed to increasing the camera format using sensors developed under an OAST RTOP task. The larger format cameras will be designed to provide large area coverage at high resolution. Fabrication and testing of a line array camera has been completed, and the design of a breadboard area array camera is nearing completion. This breadboard will serve as the design base for the feasibility model camera to be built in FY-76. In addition to demonstrating the feasibility of using a CCD sensor for planetary imaging, work will commence this year on preparing to build such an instrument for the proposed MJU'79 Mission. Spacecraft interface definition will begin, camera design characteristics will be documented, telescope/sensor integration will be initiated, and a more intensive sensor development activity will be undertaken. These activities will provide the base upon which a project funded MJU'79 Imaging Instrument can be built.

W76-70539 **186-68-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROMINIATURE TRANSPONDER DEVELOPMENT
R. R. McDonald 213-354-6186
(506-20-21; 506-20-22)

The objectives of this RTOP and the OAST RTOP 506-20-21 are to jointly develop microwave radio transponder techniques, components, and subsystem technology required for NASA planetary missions in the period 1977 to 1982. Particular emphasis will be placed on substantially reducing the cost of transponders while improving performance capability, reliability, and lifetime while reducing size, weight, volume, and power consumption. The key element of the development is a microminiature multimission transponder (MMT) consisting of an S-band receiver and an S/X-band exciter assembly utilizing such advanced devices as beam leaded RF-IC's, surface acoustic wave filters (SAWF) and ceramic substrates. Accomplishments to date include: (1) the demonstration of technology readiness of a discrete component-printed circuit board version of the MMT by the end of FY-74 (this model became the baseline design for the MJS77, Pioneer Venus and Japanese Broadcast Satellite). This version has the following advantages over the Viking Orbiter design: an order of magnitude improvement in differential phase and group delay stability; and reductions of 35% in per unit cost; 72% in power consumption; 60% in volume; and 50% in weight. (2) The development, fab and evaluation of a set of SAWF's on quartz substrates (for very low TC necessary to reduce phase delay variations) by the end of the third quarter of FY-75. (3) The development, fab and evaluation of a breadboard version (beam leaded components in nonhermetic ceramic submodules) of the MMT by the end of FY-75. By the end of FY-76 microminiature brassboard assemblies and modules will have been tested to type approval and qualification test levels to demonstrate the technology readiness for flight missions beginning in 1979 which has the following advantages relative to the discrete component version: A doubling of mission life potential (adequate for 8-year missions w/o additional redundancy); and reductions of greater than 50% in weight and volume.

W76-70540 **186-68-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GUIDANCE AND CONTROL TECHNOLOGY FOR PLANETARY MISSIONS
R. R. McDonald 213-354-6186
(506-19-14; 506-19-21)

The objective of this work is to make available a planetary star tracker suitable for use on the proposed 1979 MJU mission. This work will also provide the technology base for a standardized low cost star tracker for broad application to anticipated NASA missions from 1980 on. This star tracker has been designated by the acronym STELLAR, for Star Tracker for Economical Long Life Attitude Reference. The STELLAR makes significant improvements in reliability by utilizing an all solid-state image sensor thereby completely eliminating high voltage circuitry and vacuum tubes as used in current star trackers and in addition provides significant reductions in cost, size and weight. The STELLAR concept is a revolutionary (rather than evolutionary) departure from current star trackers and is keyed directly to the fast emerging new technology of charge coupled device (CCD's) photodetectors. The objective of the STELLAR development effort is to achieve the improvements in reliability (10 year lifetime vs 3 years), performance and cost (over 50% reduction in sensor costs) and to demonstrate these improvements in an engineering model STELLAR. This work is jointly funded by OAST ELACS RTOP no. 506-19-14.

W76-70541 **186-68-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
G&C TECHNOLOGY FOR MARS ROVING VEHICLES
R. R. McDonald 213-354-6186

The work proposed in this RTOP will provide technical assistance and direction to the NASA Headquarters University Grant NGL 33-018-091. This grant is to Rensselaer Polytechnic Institute for development of component and system technology for Mars Roving Vehicles. The JPL effort will consist of reviewing the work at RPI as well as correlating RPI's effort with ongoing work at JPL. It is understood that NASA will reduce RPI's funding during FY-76 and end the work in FY-77.

W76-70542 **186-68-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PROPELLANT COMPATIBILITY WITH MATERIALS FOR LONG DURATION MISSIONS
R. R. McDonald 213-354-6186

The objective of this work is to provide the technology for propellant/material compatibility that will be used on future planetary missions. Current objectives include work to determine which materials are acceptably inert for use in the construction of propulsion subsystem components in contact with earth storable liquid propellants for long duration missions. The test program involves continuing actual specimen storage tests in a controlled environment using the compatibility test facility at the JPL Edwards Test Station. Detailed chemical and physical analyses of specimens and propellants will be performed after specific storage periods and a rating assigned for design purposes.

W76-70543 **186-68-65**
Ames Research Center, Moffett Field, Calif.
PIONEER SYSTEMS TECHNOLOGY
D. R. Chapman 415-965-5065
(186-68-75)

The objective is to develop basic spacecraft systems using existing technology, as close as possible to Pioneer 10/11, and Pioneer Venus configurations, respectively, consistent with specific mission requirements. This will provide the basis for the realistic estimates of performance, costs, reliability, and scheduling so vital to project definition and decision making. This can only be accomplished by understanding the required technology, subsystems, and the respective interfaces. Program costs are determined by the ability to define realistic system and subsystem requirements. The approach is to concentrate on the most critical areas first; understand the technology requirements, evaluate

alternatives, and investigate the most attractive but unproven concepts. Emphasis will be placed on obtaining experimental data. Evaluation and application of existing technology will have the highest priority. All efforts will be primarily hardware-oriented and related to specific missions.

W76-70544 **186-68-73**
Goddard Space Flight Center, Greenbelt, Md.
EPHEMERIDES AND RECOVERY ANALYSIS FOR COMETARY MISSION PLANNING
R. W. Farquhar 301-982-5063

The principal goals of this RTOP are to provide and catalog up-to-date data on comets that are possible targets for proposed missions in the 1980's. For each comet and comet mission opportunity, the following data will be collected or generated: (1) orbital elements and ephemerides, (2) the evolution of cometary position uncertainties near each mission opportunity, (3) earth-based sighting data and polar plots near each mission opportunity, and (4) past physical, photometric and spectroscopic data for each proposed target comet. Using all available observations, improved orbits will be computed for target comets. Cometary ephemerides and the evolution of position error ellipsoids will be computed for the various mission opportunities. Literature searches will be conducted to gather physical observations of target comets. For each mission opportunity, earth-based sighting conditions and polar plots will be generated to facilitate the comet's early recovery by ground based observers. All data on the proposed target comets will be systematically cataloged and made available to all interested parties.

W76-70545 **186-68-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLAR ELECTRIC PROPULSION - NAVIGATION AND MISSION ANALYSIS
R. R. McDonald 213-354-6186

The objectives are the development of a comprehensive navigation accuracy analysis software system for low thrust missions and the exercise of that software for the generation of navigation accuracy forecasts and requirements for advanced SEP missions and the development, testing, and evaluation of navigation strategies incorporating advanced data types and filtering techniques. Development and utilization of a comprehensive mission analysis capability for determination, evaluation, and study of low thrust (both SEP and NEP) mission concepts. In FY-76 documentation of the existing software system will be completed, and capabilities will be expanded to narrow the gap between conservative and realistic analysis capability for future missions. Performance software to accurately simulate the low thrust hardware system and assess mission impacts of various operational strategies and constraints will be used to develop data to a limited extent for missions, such as comet rendezvous, and a description of the software initiated. Limited expansion of capability may also occur. Active cognizance over the software will be maintained to allow a timely response, on a limited scale, to questions that may arise in connection with preliminary mission performance studies or thrust subsystem development, at LeRC.

W76-70546 **186-68-76**
Ames Research Center, Moffett Field, Calif.
PLANETARY SURFACE PENETRATOR TECHNOLOGY
Dean R. Chapman 415-965-5065

Recent studies have shown that Surface Penetrators are attractive tools for exploring the solid bodies of planets and satellites. Several aspects of the science instrument design and regolith modification caused by penetration must be assessed before a penetrator mission can be approved. Studies and tests will be performed to confirm the survival of several candidate science instruments and to measure the amount of change produced in the regolith by penetration.

W76-70547 **186-68-77**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MISSION AND SYSTEM DESIGN - MJU'79
R. R. McDonald 213-354-6186
(186-68-78; 186-68-79; 186-68-80)

The objective of this RTOP is to accomplish the mission and spacecraft system design for a Mariner Jupiter/Uranus 1979 mission, such that a science payload confirmation can be made by January 1977. Conceptually, the MJU79 spacecraft design is a direct adaptation of the MJS77 spacecraft hardware, software and ground data system design. The only modifications to the MJS77 spacecraft to be considered are those that are necessary to accommodate the MJU mission; this involves three spacecraft subsystems and the science payload. A study of the incorporation of these modifications, in a spacecraft system context, will be accomplished and ultimately, a spacecraft system design will be defined. Mission design will be undertaken with initial efforts directed to those mission definition activities required to support early science selection activities. Mission design activities will conclude with a finalized mission design at the time science confirmation is made. The approach to be taken will be to form a single design team to accomplish the mission and spacecraft system design. The team will be comprised of personnel representing each of the JPL technical divisions, as well as the Project Engineering and Space Science divisions. Team representation will also include certain technical disciplines, (e.g., mission analysis) having a major involvement in the design and science payload definition activities. The team will operate under the direction of a designated team leader and by means of regularly scheduled meetings will define the MJU79 design.

W76-70548 **186-68-78**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MJU'79 BUFFER MEMORY DEVELOPMENT
R. R. McDonald 213-354-6186
(186-68-77)

The objective of this effort is to develop a no-moving-part memory for the Mariner Jupiter-Uranus 1979 (MJU-79) mission. The established Silicon-Nitride memory technology, MNOS, will be used. The memory will be capable of being used as input-output buffers for NASA Standard Tape Recorders or as a stand-alone memory to provide redundancy to the tape recorder. The memory will have the capability of graceful degradation in case of component failure. The memory will be based on a two-dimensional array of identical memory modules; the array parameters will be determined by input-output data rates, preferred degradation modes, and detailed mission peculiar requirements. The MNOS memory device will be developed and qualified starting in FY-76. In parallel with the device development, the memory architecture will be refined, and a functional breadboard based on that architecture will be designed, built and tested.

W76-70549 **186-68-79**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MAGNETIC BEARING REACTION WHEEL FOR UNMANNED PLANETARY VEHICLES
R. R. McDonald 213-354-6186
(506-19-14)

The objective of this task is to qualify the technology for the magnetic bearing reaction wheel (MBRW) initiated by the ELACS task (506-19-14) to achieve technology readiness for MJU79. An engineering model MBRW is under development at Sperry Flight Systems Phoenix and is scheduled for completion about November 1975. It is proposed that this contractual effort be supplemented to qualify the MBRW and electronics controller technology.

W76-70550 **186-68-80**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MARINER JUPITER/URANUS 1979 SCIENCE STEERING GROUP
R. R. McDonald 213-354-6186
(186-68-77)

During Fiscal Year 1976 preliminary selection will be made of the investigations for the Mariner Jupiter/Uranus 1979 (MJU 79) mission. This selection will be made on the basis of the evaluation of proposals received in response to Announcement of Opportunity No. OSS-1-75. Following selection on about December 1, 1975, the Principal Investigators will be formed into a Science Steering Group (SSG) for the MJU 79 mission.

The purpose of this RTOP is to provide funding support for this SSG. Contracts will be let to each investigator to support his activities during the preliminary phase leading to the final selection of investigations.

Physics and Astronomy

W76-70551 **188-36-55**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
D. R. Chapman 415-965-5065
(385-36-01)

The objective is to improve understanding of the dynamics, origin, and termination of the solar wind by observations and their theoretical interpretation, and by investigating techniques to improve space plasma observations. Techniques to improve the lifetime, reliability, sensitivity, sampling rate, dynamic range, and resolution of space plasma experiments are studied. Means for improvement of measurement resolutions for the individual plasma parameters, the temperature, density, velocity vector and temperature anisotropy, and investigation of techniques for improvement of calibration procedures and calibration data analysis are included. Theoretical studies provide designs of plasma analyzers for testing in the laboratory. Theoretical studies aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms, and its properties at large heliocentric distances are carried out. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments are related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind.

W76-70552 **188-36-55**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTIONS
E. R. Schmerling 202-755-3685

The objective is to: (1) investigate the processes occurring in the magnetosphere of the earth and in interplanetary space through a study of energetic neutral and charged particles and their interactions with magnetic and electric fields. Areas of investigation include trapped and auroral particles, the magnetopause, geomagnetic tail and solar wind; (2) investigate the processes which result from the arrival of solar particles near the earth, and the consequences of variations in the incident flux. Extend these investigations to the magnetospheres of other planets. The approach will be to: (1) develop instruments for measuring neutral and charged particles from several eV to several tens of MeV; dc magnetic fields from below 0.1 gamma to several oersted; electric fields and VLF wave activity; (2) develop the theory needed to understand the magnetosphere, the auroras, the solar wind, the interplanetary regions and the observed boundary effects, down to roughly the plasmapause.

W76-70553 **188-36-55**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETODYNAMICS-NON THERMAL PLASMAS
Keith W. Ogilvie 301-982-5904

The object of this research is to increase the knowledge and understanding of non-thermal plasmas occurring in nature, and also to improve the theoretical description of their properties. This requires continuous improvement in measurement techniques, and interpretation of appropriate space and laboratory experiments. The interpretation requires corresponding improvements in numerical techniques, and in methods of data display.

W76-70554 **188-36-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PARTICLES AND PARTICLE/FIELD INTERACTIONS
D. P. Burcham 213-354-3028

The Vector Helium Magnetometer is being developed for use on missions to the outer solar system where extremely weak interplanetary or interstellar fields will be measured and where intense planetary fields may also be encountered. JPL scientists and engineers carry out tests and experiments to establish the fundamental principles of the magnetometer operation and design. Improved components are developed, the design is changed to yield improved performance, and new modes of operation are investigated. The basic objective is to provide continuing theoretical support for NASA's observational space plasma programs. An analytical tool developed earlier under this task will be applied to the problem of magnetic merging at the magnetopause and to studying the influence of solar-wind thermal pressure on magnetospheric motions. To set the stage for analyzing spacecraft data in terms of solitons, a new theoretical investigation will be undertaken to determine (1) under what conditions solitons will form and propagate in space plasmas, (2) where and to what extent solitons contribute to the dynamics of space plasmas, and (3) how solitons can be identified.

W76-70555 **188-36-56**
Marshall Space Flight Center, Huntsville, Ala.
PARTICLES AND PARTICLE/PHOTON INTERACTION
G. R. Swenson 205-453-4175
(356-36-04)

The objectives of this RTOP are: (1) to update ground based instrumentation (i.e., Fabry-Perot interferometer, sector spectrophotometer, 4 channel tilting photometer, and J-5 sounder); (2) to measure, in support of IMS, at MSFC, nightglow wavelength 6300 temperatures and winds (F region), to measure wavelength 6300, 5577, 5200, and OH intensities in nightglow, and provide the data in a usable form to the World Data Center in Boulder, Colorado; (3) to make measurements at a Polar Cusp Station of particle related emissions from the ground to determine rotational temperatures and related spectroscopic emission intensities in the (hot) cusp region and to make these measurements in coincidence with AE-D satellite for particle and photometer information; and (4) to do theoretical studies on the geophysical results.

W76-70556 **188-36-56**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETOSPHERIC PHYSICS: PARTICLES AND PARTICLE/PHOTON INTERACTIONS
James P. Heppner 301-982-4797

The objectives are: (1) to conceive, design, develop and test new techniques for space measurements of electric fields, auroral particles, trapped particles, solar-interplanetary particles, plasma waves, wave-particle interactions, photon-particle interactions, plasma composition, ionospheric winds, electron density and atomic and molecular collision processes with particular emphasis on magnetospheric and ionospheric regions, and (2) to analyze problems and conduct theoretical studies in magnetodynamics, plasma physics, and atomic and molecular interactions. The approach includes detector and supporting electronics, design, laboratory and contractor fabrication and testing, and theoretical studies of field and particle phenomena and distributions in space. This effort is expected to produce: (1) instrumentation having the capability to make measurements that previously have not been possible, particularly in areas where there are significant gaps in our knowledge as a consequence of there being few or no measurements, (2) accurate models of fields in space which have both scientific and technological utility, (3) indices which describe the instantaneous degree of disturbance in the ionosphere and magnetosphere, (4) advances in the understanding of plasma instabilities, and (5) new techniques for studying the transport of ion and neutral particles in the ionosphere.

W76-70557 **188-36-56**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS
E. R. Schmerling 202-755-3685
(188-36-57)

The objective is to investigate the absorption of solar photons and particles in the earth's upper atmosphere, the processes by which the absorption products are dissipated, and the effects which arise therefrom. Included are the collisional, photochemical and electromagnetic interactions which are found in the upper atmosphere, the ionosphere and the inner magnetosphere. These investigations are also applied to the atmospheres, ionospheres and inner magnetospheres of the planets. The approach will be the development of instruments for the direct and indirect measurement of near-thermal plasmas, neutral gaseous constituents, electric and magnetic fields. Coordinated investigations will be conducted for cause-and-effect studies, together with the development of the appropriate theories. The region covered extends roughly from the lowest ionosphere to the plasmapause.

W76-70558 **188-36-56**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS (AERONOMY)
D. R. Chapman 415-965-5065
(185-47-67)

The objective is to investigate the physics of the earth's topside ionosphere and plasmasphere and the coupling of these regions with the magnetosphere and solar wind. Theoretical studies of the thermal charged-particle composition, density, and temperatures are being performed. Computer programs are being coded based on the continuity, momentum, and energy balance equations appropriate to these regions. Data from the Alouette, ISIS, and other satellites will be used as boundary conditions. Special correlative studies are also being performed to investigate the global nature of certain anomalous features; i.e., the plasmapause and ionospheric troughs. The results of these efforts are vital to the understanding of the earth's charged particle environment and have application to communications between terminals immersed in these media. The theory and techniques involved are applicable to the studies of atmospheres and ionospheres of other planets and their effects on radio communications of space probes. Preliminary efforts are being initiated to investigate the charged particle environment of the Venus and Jupiter ionospheres.

W76-70559 **188-36-57**
National Aeronautics and Space Administration, Washington, D.C.
MAGNETOSPHERIC PHYSICS - RADIO SCIENCE
E. R. Schmerling 202-755-3685
(188-36-56)

The objective is to investigate the interplanetary medium, the environments of the earth, the moon, the planets, and the sun, as well as celestial mechanics and relativity, by the propagation or scattering of radio waves. The approach will be to develop techniques for interpreting the refraction, scattering, polarization rotation and phase shifting of radio signals occurring naturally or generated artificially in terms of physical properties of the intervening medium. To develop instruments for generating electromagnetic waves in space and measuring the effects of the medium, together with the appropriate theory. To model, in the laboratory, the plasma interactions and resonances observed in space, and to test the theories developed to explain them. To investigate the interaction between radio waves and energetic particles in the environments of the sun, moon, and planets.

W76-70560 **188-36-57**
Goddard Space Flight Center, Greenbelt, Md.
APPLICATIONS OF THEORETICAL SPACE PHYSICS
T. G. Northrop 301-982-4441

Theoretical investigations are presented of a dozen or more areas of space plasmas and of cosmology. These include: (1) cosmic ray origin and propagation, (2) supernova explosions, (3) fluxes of electrons and protons observed by Pioneers 10 and 11 in Jupiter's magnetosphere, (4) sources of galactic gamma rays, (5) ozone dynamics in the upper atmosphere, (6) dynamics of earth's magnetosphere, (7) fluid dynamics and Martian cloud patterns, (8) scintillation of radio sources and solar wind, and (9) big bang cosmology.

W76-70561 **188-38-51**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF EXPERIMENTS AND HARDWARE FOR SOLAR PHYSICS RESEARCH
J. F. Osantowski 301-982-5861

A research program was initiated to develop or improve critical technology items principally, but not exclusively, for solar physics research and to supply critical data required by scientists in designing and/or proposing advanced instrumentation for space or ground based observations. Specifically, the development of specialized optical components, the development or improvement of optical instrumentation, and the development or improvement of various techniques or instruments for support of solar observations is included. To accomplish this objective GSFC is conducting in-house, University grant, and contract experimental and theoretical studies in the following technology: (1) design, fabrication, and testing of glancing incidence optical systems for the 8A to 300A spectral region including the problems of increased energy throughput and scattering, and (2) diffraction grating technology including holographic grating development. Other technology areas will be included to support current programs or problem areas identified by the solar physics community. References for identifying key technology include NASA Document SP-213, 'A long Range Program in Space Astronomy', final report of the Space Shuttle Payload Planning Solar Physics Working Group Report and the Space Science Board Report - Scientific uses of the Space Shuttle.

W76-70562 **188-38-52**
Marshall Space Flight Center, Huntsville, Ala.
GROUND-BASED OBSERVATION OF THE SUN
M. J. Hagyard 205-453-5687
(357-38-01; 385-38-01)

The Real Time Solar Magnetograph (RTSM) is designed to study small scale variations in the sun's magnetic field in order to determine their role in solar activity. The system uses a narrow bandpass filter, polarizing optics and an SEC vidicon camera system to measure linear and circular polarization in Zeeman-sensitive chromospheric absorption lines. An H-alpha telescope and Brightness Distribution Analyzing (BDA) system are operated in support of the RTSM for active region identification and flare classification. In direct support of the RTSM, theoretical work is being performed with the objectives of (1) interpreting the basic phenomena associated with solar active regions by studying the interactions of the solar plasma with local magnetic fields, and (2) reducing, analyzing and correlating solar data on the basis of these plasma magnetic field interactions. To accomplish these objectives, the following tasks will be performed; real time solar magnetograph, and theoretical description and data analysis of solar active regions.

W76-70563 **188-38-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND BASED OBSERVATIONS OF THE SUN
J. C. Brandt 301-982-4701

The Zeiss filtergraph at the GSFC Optical Site will be modified for the objective of recording and analyzing solar velocity fields. Our approach will be to utilize a state-of-the-art dual bandpass H-alpha filter, together with vidicon equipment for image handling. Three-color photometry of the corona, to develop a new model, remains as an objective. The present system will be reconfigured for use at the 1976 Australian eclipse. The approach will be modified to take advantage of USAF support equipment and to substitute Reticons for the present Digicons. The present objective of the vidicon systems is to obtain data on chromospheres and possible 'solar winds' and 'solar activity' of other stars, using as an approach the McMath Solar Telescope and vertical spectrograph at Kitt Peak. The objective of radio observations under this RTOP is to search for recombination lines of heavy elements in the solar corona and the approach is to use the millimeter wavelength radio telescope of the University of Texas and also the one maintained by NRAO on Kitt Peak.

W76-70564 **188-38-53**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENTAL DEVELOPMENT - LABORATORY AND

THEORETICAL SOLAR PHYSICS
J. C. Brandt 301-982-4701

Research toward improved systems for solar observations in the EUV, X-ray and gamma ray regions is being pursued through the development of prototype collimator systems and detectors for these wavelengths. Research into improved hard X-ray detectors emphasizes the objective of extending the energy range of observation to 20 MeV. Use of a passive Li impregnated Bismuth shield offers a substantial improvement over existing methods. Electronics are being developed which together with existing crystal and mechanical fixtures, will produce a detector able to record the spectrum of a solar X-ray burst with 100 milliseconds resolution. Design of high resolution coronal spectrometer/polarimeters for the wavelength ranges 1-20 angstroms and 1200-1500 angstroms is underway and bench testing will be carried out. Microprocessors will be evaluated for application to solar experiments on satellites and sounding rocket missions. Integrated circuits of the buffered COS/MOS type will be tested in typical solar space experiment subsystems. Further development of the infrared upconversion technique will emphasize application to spectroscopy. Feasibility of an integrated optics approach to upconverting imagery will be evaluated. Fabrication and evaluation of a GaAs Digicon will be attempted. Solid state diode arrays will also be tested in conjunction with circuits fabricated by us. Methods for improved solar observations include the development of an improved millimeter wave radiometer. Extensive laboratory work is performed to support ultraviolet solar observations made from space vehicles, this includes work in our own facility and work as guests at a fusion-class laser facility.

W76-70565 **188-38-53**
Langley Research Center, Langley Station, Va.
LABORATORY AND THEORETICAL SOLAR PHYSICS
E. S. Love 804-827-2893

The principal objective is to experimentally determine rate coefficients for ionization and excitation by electron impact for various stages of ionization of elements of astrophysical interest. These coefficients play an important role in the determination of the ionization balance in nonequilibrium astrophysical plasmas such as the solar corona. Elements to be investigated include carbon, nitrogen, oxygen, neon, and silicon which are also of interest in a large number of laboratory experiments. In addition, a compilation of spectroscopic data for atomic spectral lines below 2000 Angstroms will be maintained. The theta-pinch facility is uniquely suited for the investigation of collisional rate coefficients since in the initial shock heating phase the atomic processes are dominated by electron collisions. Accurate measurements of electron number density and electron temperature are obtained by the Thomson scattering of ruby laser radiation. Plasma will be heated to a temperature of two million to three million K in about 00003 sec. This is adequate to produce the high stages of ionization found in the solar corona. Electron collisions will be the dominant process during the shock heating phase. Observation of the time of peak emission of the resonance line of each stage of ionization and a measurement of the electron number density and electron temperature at that time give the needed information to determine rate coefficient from a time-dependent corona model computer code. Excitation rate coefficients will be determined by measurements of the absolute emission coefficients for selected lines. These emission coefficients are related to the excitation rate coefficients by use of a collisional-radiative model.

W76-70566 **188-38-64**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF SHUTTLE PAYLOADS FOR THE STUDY OF SOLAR FLARES AND FLARE RELATED PHENOMENA
K. J. Frost 301-982-4811

The Laboratory for Solar Physics and Astrophysics and Optics Branch, Mission Technology Division, GSFC, propose to build a group of instruments to observe solar flares and related solar phenomena from shuttle sortie and free-flier platforms in 1979, 1980 and 1981. The scientific objective of this payload will be to advance our understanding of the nature of the mechanism of a solar flare. This will be done by observing a flare over a wide range of the electromagnetic spectrum from the visible to the gamma ray region. A number of different instruments will be required to cover this range. They will be selected on the basis of making comprehensive measurements in their specific wavelength regions in a format which is coordinated with and complimentary to the other instruments in the payload. For example, all instruments will operate with the same temporal and spatial resolution to the maximum possible extent. The instruments considered for this payload are: (1) a solar telescope (photoheliograph) with aperture greater than or equal to 65 cm, (2) a high resolution 1000-2850 A spectrometer used at the focus of the telescope and observing line profiles from the chromosphere and the transition region, and (3) digital imaging devices for measuring line profiles with high time spatial resolution.

W76-70567 **188-41-51**
Marshall Space Flight Center, Huntsville, Ala.
UV AND OPTICAL ASTRONOMY
Edgar R. Miller 205-453-0108

The scope of the UV and Optical Astronomy RTOP is being reduced to one task concentrating efforts towards utilizing a unique integrating digital video detector system which allows very high temporal resolution on faint objects and small telescopes. The change in scope also reflects the change in personnel and priorities. Specifically, the objective of the task will be to measure short term variability of several X-ray sources. Ostriker and Davidson have shown that time variation of X-ray sources can help in building models of these sources. The video system used in conjunction with a low resolution (Boro-Spotz) spectrograph allows digital recording and analogue display with spectra to be recorded on one TV frame, providing data compression capability and hence much easier data reduction. The system also provides observer interaction, since any digitally tape recorded spectra can be recalled and, for instance, be compared with any successive spectra by placing item on the screen on the same frame.

W76-70568 **188-41-51**
Lyndon B. Johnson Space Center, Houston, Tex.
ULTRAVIOLET STELLAR SPECTROMETER DEVELOPMENT FOR SPACE SHUTTLE
Y. Kondo 713-483-6467

The objective is to develop astronomical space-UV instrumentation for use in shuttle sortie missions, which will demonstrate state-of-technology detector and tracking performance, flexibility of interfacing instrumentation with a general purpose telescope platform, and versatility of man's real time operational involvement. The development of the ultraviolet stellar spectrometer for space shuttle is performed through the flights of the balloon-borne ultraviolet stellar spectrometer (BUSS) payload as well as through other concurrent laboratory-based developments. The BUSS payload performs high resolution spectrophotometry of astronomical objects in the mid-ultraviolet. The first version of the BUSS payload has been developed and flown successfully three times. It comprises a pointable telescope (40 cm aperture, f/7.5 modified Ritchey-Chretien) to which a variety of instrumentation can be attached. Payload functions are commanded from the ground in real time, and the data are telemetered to the ground in real time, where they are monitored in real time and recorded. Further development of the payload is planned in conjunction with the collaborative program with the Space Research Laboratory, Utrecht, the Netherlands. In this collaborative program, we shall jointly investigate stellar UV spectra in the range 2000-3400 A with a resolution of 1/10A, employing an echelle spectrograph in combination with an image intensified storage vidicon detector. Subsequent flights will develop the star tracking system for targets as faint as 10th magnitude and for improved spectral resolution.

W76-70569 **188-41-51**
Goddard Space Flight Center, Greenbelt, Md.
UV AND OPTICAL ASTRONOMY
A. Boggess 301-982-5103

The objective is to pursue a long range program in astronomical research with emphasis on optical observations, theoretical astrophysics, and other specific topics of special interest to NASA.

The effort includes operation of ground telescopes, development of new instrumentation for ground and rocket use, data interpretation, and theoretical studies. Spectroscopic and photometric data are obtained from ground and rocket telescopes in order to analyze the properties of stellar atmospheres, nebulae, and the interstellar medium. Model atmospheres are being developed to compare with observation, particular attention being paid to non-equilibrium phenomena. Additional tasks include calculations of fundamental physical parameters of astrophysical interest, investigations of convective energy transport, and some stellar population problems.

W76-70570 **188-41-51**
Ames Research Center, Moffett Field, Calif.
THEORETICAL ASTROPHYSICS
D. R. Chapman 415-965-5065

The objective is to conduct theoretical studies on important fundamental problems in astrophysics and astronomy and to provide theoretical advice and technical assistance for the center program on observational infrared astronomy. Astrophysical theory and mathematical techniques will be used, together with available observational data, to develop self-consistent theoretical models for the investigation and interpretation of astrophysical phenomena. Application will be made to a wide range of problems including the time variability of quasars and of X-ray sources, pre-main sequence stellar evolution, structure and evolution of white dwarfs and binary star systems, galactic evolution, interpretation and airborne infrared observations of stars, planets, and H II regions, and others.

W76-70571 **188-41-51**
Langley Research Center, Langley Station, Va.
UV AND OPTICAL ASTRONOMY (COMPUTATIONAL PHYSICS)
E. S. Love 804-827-2893

New and improved computer models will be developed to investigate the evolution and structure of various systems of astrophysical interest, such as spiral galaxies, the asteroid belt and Saturn's rings. Galaxy related problems that will be studied are how the bar-forming instability can be stabilized to allow formation of normal spirals and the method by which spiral galaxies transfer their angular momentum outwards. Another problem to be investigated is the density wave theory proposed to explain the spiral structure of galaxies. Computer experiments testing the density wave theory without making the approximations required in an analytical treatment will be performed. A three-dimensional computer model recently developed will be used to investigate the development of flat or disk systems from originally elliptical or spherical systems. A hybrid computer model containing both a stellar and gas component will be developed to more realistically simulate the dynamics of spiral galaxies. Numerical experiments on the evolution of the asteroid belt will be performed. In particular, resonant effects caused by the commensurability of asteroids with Jupiter will be investigated. Similar calculations will be made for Saturn's rings. Another problem to be investigated is the particle acceleration and other phenomena occurring in solar flares. It appears that particle acceleration occurs near magnetic neutral points and involves magnetic flux annihilation in solar flares, in laboratory experiments such as the plasma focus, and possibly also in phenomena on a galactic scale.

W76-70572 **188-41-51**
National Aeronautics and Space Administration, Washington, D.C.
ULTRAVIOLET (UV) AND OPTICAL ASTRONOMY
J. D. Rosendhal 202-755-3687

The objective is the advancement of stellar and galactic astronomy through observations and interpretations of data secured in the ultraviolet and visible electromagnetic portions of the spectrum. The emphasis is on research in direct support of on-going flight programs or in anticipation and preparation for future ones. The four elements supported are laboratory astrophysical studies, theoretical astrophysics, instrumentation development, and direct observational programs. A balanced program involving all these elements is required in order to insure full utilization and healthy development of the space science order to insure full utilization and healthy development of the space science program with the goal of the advancement of our understanding of the universe. The approach includes: developing theoretical models, performing theoretical studies, and determining basic atomic and molecular parameters. Interpretation of data, especially that obtained in the relativity unexplored UV spectral region, requires the additional information provided by these efforts. A broad and sound theoretical framework allows new observations to be interpreted and new directions to be instituted. In addition to atomic and molecular physics, specific areas of study include stellar atmospheres, stellar systems, and cosmology.

W76-70573 **188-41-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED RADIO ASTRONOMY
R. G. Stone 301-982-4631
(161-05-03; 369-05-03)

The objective of the Ground Based Radio Astronomy Program is to provide a better understanding of the dynamics and composition of astrophysical plasmas in objects such as radio galaxies, quasars, supernovae, pulsars, and solar system sources such as the Sun and Jupiter through the high angular and time resolution observations of radio emission from these objects. Radio astronomy has provided new insight into such problems which could not have been gained from observations in other parts of the spectrum as the visible or UV region. The interpretation of source spectral and spatial distribution in terms of our knowledge of plasmas and high energy processes leads to knowledge of the evolution of the source and of the magnetic field, energetic particle composition and dynamic processes within the source. The approach taken involves the use and development of high resolution radio telescopes which permit remote observations of phenomena occurring in extensive and inaccessible regions. The development of radiometers for spectral observations in the frequency bands of the principal atmospheric absorption lines will be initiated. A great deal of our knowledge about the evolution of dust clouds into stars in our galaxy has come from the study of interstellar molecular lines. These lines are concentrated in the millimeter region of the radio spectrum. Part of the mm spectrum is obscured by atmospheric absorption lines. As a result several important lines of astronomical interest such as HCN, O2 and O3 require observations above most of the atmosphere. Development will concentrate on high frequency mixers and frequency lock loops at 60, 120 and 180 GHz. Radiometers and spectral line.

W76-70574 **188-41-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GROUND-BASED RADIO ASTRONOMY
D. P. Burcham 213-354-3028

This RTOP uses the unique facilities of NASA's Deep Space Instrumentation Facility (DSIF) to find microwave spectral lines of interstellar atoms and molecules at X-band (8 GHz) and K-band (15 GHz), regions in which NASA's receiving capabilities are the best in the world. Concurrently, a laboratory microwave spectroscopy program is carried out to measure frequencies, absorption coefficients and cross sections for presently known interstellar molecules and for other molecules whose presence in the interstellar medium is strongly predicted by theory. DSIF equipment to be used includes the 64 m Goldstone antenna; K-band and X-band wideband low noise feeds, masers, and receivers; a wideband digital correlator spectrum analyzer; calibrated noise sources; and programmable local oscillators. This DSIF equipment either already exists or is being developed for programs supported by the Office of Tracking and Data Acquisition (OTDA). The spectrometer system to be used in the laboratory investigations includes a Stark Modulation Spectrometer and associated programmable digital data handling and control equipment. Fundamental questions in stellar and galactic evolution to be answered by interstellar microwave spectroscopy include the galactic molecular and isotope distribution and the isotopic abundance ratios; the velocity distribution of interstellar material; and the causes of anomalous interstellar molecular spectral line intensities. Of particular interest is the location and abundance

of complex interstellar molecules, because the mechanism that allows the creation and retention of such molecules is presently unknown. In addition, timing and intensity measurements are performed for 22 pulsars.

W76-70575 **188-41-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RELATIVITY & CELESTIAL MECHANICS
D. P. Burcham 213-354-3028

The astrophysical consequences of missing matter in the universe is being studied, first by formulation of general models with conducting plasma matter content. This research will support interpretation of data on intergalactic matter, its composition, excitation and ionization history, which will result from far ultraviolet quasar spectra taken with the forthcoming IUE satellite. The solution of Einstein's equations for selected anisotropic cosmological models is being investigated. Consequences for observational cosmology have been considered. This research has supported a study and proposal for measurement of large scale anisotropy of the Cosmic Microwave Background Radiation to be made from a Scout-launched Explorer satellite. Advances in techniques of nonlinear applied mathematics are being applied to selected problems of relativistic gravity, in particular to the calculation of fields of axisymmetric spinning sources, and to gravity waves. Research is being performed on the interaction of gravitational radiation with Doppler spacecraft tracking measurements, and on possible detection of gravitational radiation by simultaneous tracking of several spacecraft.

W76-70576 **188-41-54**
National Aeronautics and Space Administration, Washington, D.C.
RELATIVITY
N. G. Roman 202-755-3649

The primary objective is to make experimental tests of the theory of relativity and thereby elucidate the interrelationship among space, time, and gravity. In particular, the test of Einstein's General Theory of Relativity is paramount. This formulation is fundamental and of high scientific interest. Experimental verification is difficult but the ability to orbit large, complex, and extremely precise apparatus, shielded from deleterious perturbations should obviate them. In addition to the scientific goals, improvements and innovations in the technological areas of cryogenics, gyroscope design, and precision clocks are expected. Specific objectives include the development and operation of a flight qualified cryogenic gyroscope, complete gyroscope system error analysis, and the consideration of various theoretical formulations of relativity and their subsequent experimental implications. Possible future benefits apart from the scientific ones include improved timing for navigation, communication and geodesy as well as cryogenic systems capable of extended operation in space.

W76-70577 **188-41-54**
Marshall Space Flight Center, Huntsville, Ala.
RELATIVITY AND CELESTIAL MECHANICS
Richard A. Potter 205-453-3431

The objective of this activity is to develop the technology required to support and lead to a demonstration of the Stanford Relativity gyro experiment. Two or more gyroscopes, with their associated dewar will be flown in the spacelab or shuttle bay to establish the gyroscopes's ability to operate and function in a near zero gravity environment. The well coordinated, theoretical, experimental and engineering program at MSFC and Stanford University will be tailored to development of an experiment system that will prove the required technology during the early shuttle time period.

W76-70578 **188-41-55**
Lyndon B. Johnson Space Center, Houston, Tex.
INFRARED SPECTROSCOPY OF STARS
A. E. Potter 713-483-2071

The overall objective is to clarify the structure and nature of cool stars. Specific objectives are to determine accurate continuum energy distributions for typical C, M and S-type stars throughout their phase variations. Results will be fitted to model stellar atmospheres in order to account for the properties of these stars, and to determine the abundance of various molecular species in late-type stars in order to estimate their importance as opacity sources. In addition, the extent and distribution of circumstellar matter in early-type stars will be examined by obtaining the spectra of these stars in the 1-1.6 micron region and using the emission in the hydrogen and helium lines to determine distribution of the material and physical condition in these gaseous distributions. Specific objectives are: (1) qualitative comparisons of the similarities and differences in the line spectra among these stars, and (2) detailed calculations of the line shapes of the 1-1.6 micron helium and hydrogen lines in Be stars for various model envelopes. Near infrared spectra of appropriate stars will be measured using a Michelson interferometer. The available instrument is capable of spectral resolutions to 0.05/cm in the 1-1.6 micron range.

W76-70579 **188-41-55**
Goddard Inst. for Space Studies, New York.
MILLIMETER-WAVE AND FAR INFRARED ASTRONOMY
Patrick Thaddeus 212-678-5621

The main scientific purpose is (1) to observe interstellar molecules at millimeter and submillimeter wavelengths, in order to study the dynamics of dense interstellar clouds, the process of star formation, isotopic ratios, interstellar chemistry, and other astrophysical topics, and (2) to obtain laboratory data on molecular spectra in order to interpret these observations, and in order to search for new molecules in space. The main technical purpose is to extend radio frequency techniques into the far infrared for use on aircraft and space vehicles. The approach involves the design, construction, and test of millimeter-wave receivers, observations using these with existing radio telescopes, and back-up laboratory measurements.

W76-70580 **188-41-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INFRARED ASTRONOMY
D. P. Burcham 213-354-3028

The objective of this task is to obtain and analyze absolutely-calibrated high resolution near infrared (1-6 micron) spectra of late-type stars and variables. The program is a collaborative effort between JPL and the University of Texas at Austin and involves a joint observing program using the JPL Fourier Spectrometer at the 2.7 m telescope, McDonald Observatory, model atmosphere analyses and spectrum syntheses in Austin, molecular physics at JPL and stellar interior modelling at JPL. From these data, we hope to learn more about the composition, structure and evolution of these projects.

W76-70581 **188-41-55**
National Aeronautics and Space Administration, Washington, D.C.
INFRARED ASTRONOMY
N. W. Boggess 202-755-3688

The objective is to advance stellar and galactic astronomy in the spectral region between 1 and 1000 microns through observational and theoretical programs. Observations in the infrared portion of the electromagnetic spectrum are particularly important for an understanding of the early and late stages in stellar evolution, interstellar matter, galaxies and quasistellar objects and the energy mechanisms associated with them, and the residual radiation of the universe. A balanced program including observation, technique and instrumentation development, and theory is required to insure the advances needed for full utilization of future platforms in space. The approach includes the following elements: (1) support observational programs using ground-based telescopes, balloons, and airplanes; and (2) promote the development of infrared techniques and apparatus. Special emphasis is placed on far IR narrow band filters, spectral interferometers; modulation techniques, and multiple detector arrays in order to enhance the information content of an observation; and more recently, on development of cryogenic and low-background telescopes.

W76-70582 **188-41-56**
Goddard Space Flight Center, Greenbelt, Md.

FAR INFRARED ASTRONOMY
Michael Hauser 301-982-2468

The scientific objective of this new program is to observe stellar, interstellar and extragalactic sources of far infrared (10-1000 micron) radiation in order to study many astrophysical problems, such as early and late phases of stellar evolution, the composition and dynamics of the interstellar medium, the energetics of high luminosity galactic and extragalactic sources, and the structure and history of the Universe. Since atmospheric opacity and emissivity prohibit or severely limit ground-based observations, high altitude observational platforms such as balloons and satellites must be developed to permit sensitive astronomical measurements in this spectral range. High detectivity composite bolometers will be developed to take maximal advantage of the low background conditions achievable at these altitudes.

W76-70583 **188-41-57**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LABORATORY ASTROPHYSICS
D. P. Burcham 213-354-3028

Laboratory data will be obtained to support the theory of interstellar molecular synthesis by ion-neutral reactions in cloudy regions of condensed material between stars. Up to now, theoretical studies which model interstellar synthesis by ion-neutral reactions have had to rely, to a large degree, on assumed reactions and assumed rate constants. Those reactions and rate constants which are of most pressing interest for interstellar molecular synthesis can be measured in the JPL Ion Chemistry Laboratory using the ion cyclotron resonance (ICR) technique. The reactions of atomic ions (H(+), C(+), N(+), O(+)) and simple hydride ions (CH(+), NH(+), etc.) with the most abundant neutral molecular species (H2) have been measured in this laboratory. In order to study the reaction of ions with atoms and radicals (H, CH, OH, etc.), the ICR spectrometer will be modified to produce these unstable neutral species. Those electron-molecule collision processes which play an important role in interstellar chemistry will be studied. Cross sections for these processes, and radiative lifetimes of the excited species will be determined in molecular beam/electron beam scattering experiments, and by electron-photon coincidence measurements, respectively. The methods of electron-impact spectroscopy will be used to identify metastable states of molecules which are not observable via photon excitation. The measurements will be carried out on H2,NO,CH4,NH3,H2S,CH3OH, and HCN in a manner that correlates these measurements with all the available experimental and theoretical data.

W76-70584 **188-41-64**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY ASTRONOMY FOR SHUTTLE
Elihu A. Boldt 301-982-5853

Celestial X-ray sources have introduced us to rich new aspects of astronomy ranging from the millisecond bursts of hard X-rays coming from the innermost orbits of matter falling into a black-hole to the broadened K lines emitted by subrelativistic cosmic ray iron nuclei ejected into the interstellar gas from recent supernovae such as Cas A. The combination of large sensitive area, low detector background, high temporal resolution and non-dispersive spectroscopy over a broad bandwidth has been our approach in discovering and exploring these phenomena. The power of this approach is being well demonstrated. Extending it with improved spectral resolution and broad-band imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise ionization counters of optimum resolution, large area X-ray concentrators, imaging counters and associated scatter-hole camera configurations. The laboratory-type operation and high telemetry capability of the shuttle make it particularly appropriate for the effective application of such instrumentation to new experiments in X-ray astronomy.

W76-70585 **188-45-51**
Goddard Space Flight Center, Greenbelt, Md.
COMETS AND INTERSTELLAR MATTER
B. D. Donn 301-982-5014

This RTOP includes several programs to study interplanetary and interstellar matter. The primary objective is laboratory experimentation relevant to the physicochemical behavior of matter in space. Theoretical analysis of astronomical problems using experimental and theoretical results is a second aim. A third aspect involves observations from spacecraft to obtain new data. The last phase uses ground based telescopic observations. Molecular beam, laser techniques, and resonance fluorescence are being used for measuring production and reaction of atoms, radicals and ions from planetary, cometary or interstellar molecules by impact of photons, electrons and ions. The optics, spectroscopy and chemistry of species appropriate to the study of interstellar molecules and grains will be investigated. The possible relation of cometary and interstellar molecules to star formation chemical evolution and the origin of life will be examined. In support of other research use of image intensifiers to study comets and interplanetary matter will be investigated.

W76-70586 **188-45-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
COMETS
D. P. Burcham 213-354-3028

It is the objective of this RTOP to coordinate a program of ground-based observations, laboratory work, and theory addressed particularly toward a quantitative understanding of the physical processes which give rise to the phenomena of nucleus, coma, and tails called a comet. A further objective is the intercomparison of many comets in order to enhance the value of data taken on those few that become targets for space missions. The observational program will be carried out at the Table Mountain, Mt. Wilson, and Mauna Kea Observatories. Emphasis will be placed on using the SIPS (silicon imaging photometric system) to obtain two-dimensional photometry of comet comae and tails. These maps will be used to determine the distribution of emitting species in comet comae. The laboratory studies programs are directed towards understanding photochemical processes in comets and mechanisms of cometary halo production. Theoretical modelling which incorporates both the observations and laboratory work will be used to develop models of cometary structure. Both neutral and plasma gas distributions will be included in the modelling.

W76-70587 **188-45-52**
Marshall Space Flight Center, Huntsville, Ala.
INTERPLANETARY DUST AND COMETARY PHYSICS
Nicholas C. Costes 205-453-0946

A broad multidisciplinary approach will be applied to problems related to the origin, composition and physical properties of solar-system small bodies, combining the experience in optical scattering and surface phenomena developed in the Skylab Optical Contamination program, the experience in the properties of porous material developed in the Apollo lunar surface investigations, and the experience with developing and applying state-of-the-art electro-optical observing and automated analysis techniques developed previously under this RTOP. The observational objectives are to obtain statistical data on the composition of shower and sporadic meteors through spectral analysis; obtain distribution functions for meteor masses in the range from 0.000001 to 100 grams as a function of hour and season; to map shower profiles in order to obtain the effects of perturbations on the shower components; and to obtain spectral, photometric, and polarimetric data on targets of opportunity such as comets or asteroids that may become visible. Supporting laboratory studies will include the study of simulated cometary structure and physical properties by means of vacuum sublimation of aggregates of various minerals and ices at cryogenic temperatures. Evaporation rates of various ices as a function of impurities under solar simulation will be studied, and photo-dissociation and excitation of the evaporating molecules will be measured. Finally, attempts will be made to relate the research results into a coherent picture of the behavior of comets and the dust they produce.

W76-70588 **188-45-52**
Langley Research Center, Langley Station, Va.
METEOR ASTRONOMY - OBSERVATIONS, SPECTRA, AND DATA ANALYSIS

E. S. Love 804-827-2893

The primary objective is to obtain trajectory, orbital, and spectral data of chemically differentiated meteors, and of other meteors of special interest. Additional objectives include radiation studies, and studies of earth-orbital, far-UV meteor spectroscopy. Preparations for far-UV meteor photometry and spectroscopy from space-shuttle launched platforms, LDEM and ATL, will be made. Calibration and data reduction procedures for the UV region will be developed. The research will be accomplished by operating and upgrading the two-station, direct-photography and meteor spectra patrol. Statistical studies of data in hand and detailed reduction of selected data will continue. Radiation studies, particularly of self-absorption and energy partition will continue. An engineering model of a far-UV meteor detector/photometer will be developed for intended use on an Explorer class spacecraft and for the space shuttle ATL. A UV photometer experiment will be developed for the Long Duration Exposure Facility.

W76-70589 **188-45-53**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

COSMIC DUST MEASUREMENTS

D. P. Burcham 213-354-3028

The objective of this work is to develop a focal plane mass spectrometer with an extremely sensitive ion detector which would allow the simultaneous collection of all ion beams over the mass region of interest. The high sensitivity is particularly important for the analysis of cometary atmospheres where very low densities are likely to be encountered and the ability to optimally trade-off sensitivity and spatial resolution is currently constrained by low duty cycle, scanning instruments. The approach would be to work closely with Professor A. O. C. Nier of the University of Minnesota who will provide hardware and science support in concert with an electro-optical detector development at JPL. The present concept of the detector is to place a micro-channel electron multiplier array at the focal plane of the mass spectrometer where the ion beam signals are converted to electrons with an amplification of greater than or equal to 10,000. The resulting electron beams would impinge upon phosphor coated fiber optics yielding photons which are directed to a photodiode linear array.

W76-70590 **188-45-53**

Ames Research Center, Moffett Field, Calif.

COLLECTION AND ANALYSIS OF METEOR DEBRIS FROM THE ATMOSPHERE

D. R. Chapman 415-965-5065

(176-61-11; 743-02-22; 195-21-04)

The objectives are to compare the properties (elemental and mineralogical) of material collected in the atmosphere after a meteor fireball event with the debris ablated from meteorites, and the cosmic dust background level in the stratosphere. The particulate collections will be obtained using basic instruments currently available and on board the U-2 aircraft supporting Ames stratospheric research program (RTOPs 176-61-11 and 743-02-22). The collection will be attempted on meteor fireballs with magnitudes of approximately -10 or greater within 30 hours of the event (to ensure largest possible particles will be collected) at an altitude of approximately 20 km. The flight path will be determined using ground observation data and a meteor fireball wake distribution pattern based upon known stratospheric wind conditions employing a classical atmospheric fallout model. The analyses to be performed on collected specimens will include optical mineralogy, petrography, density, X-ray diffraction, electron microprobe, scanning electron microscope, laser microprobe, and ion microprobe. These results will be compared with current data describing physical properties of aerosols in the stratosphere and those characteristics of meteor ablation debris obtained from studies on meteorite fusion crusts and results obtained during artificial meteor ablation experiments.

W76-70591 **188-46-52**

Goddard Space Flight Center, Greenbelt, Md.

THEORETICAL HIGH ENERGY ASTROPHYSICS

R. Ramaty 301-982-4715

The objectives are: (1) to conduct theoretical research in high energy astrophysics with particular emphasis on areas of interest to the general program of the Laboratory for High Energy Astrophysics, (2) to provide support of graduate students from the University of Maryland to participate in research leading to doctoral dissertations in theoretical astrophysics, (3) to publish in the scientific literature the relevant and significant results obtained from research carried out by members of the group, and (4) to provide theoretical support for satellite experiments and mission definition studies, conducted both within and outside the Laboratory for High Energy Astrophysics. The Theoretical Group in the Laboratory for High Energy Astrophysics consists of two civil service employees (R. Ramaty and L. A. Fisk), one or two National Academy Research Associates (B. Kozlovsky, 1973-74; C. Ryter, 1974-75), and three graduate students (H. T. Wang, T. Bai and R. Bussard). Members of the group have maintained a high level of theoretical expertise in high energy astrophysics and have attempted to contribute to and keep abreast with new developments in this area of astronomy. Using this expertise, they initiate and support theoretical research in the Laboratory for High Energy Astrophysics. They have also contributed to the weekly Goddard-University of Maryland Astrophysics Seminar both as lecturers and as advisors on topics and potential speakers.

W76-70592 **188-46-56**

National Aeronautics and Space Administration, Washington, D.C.

PARTICLE ASTROPHYSICS

Albert G. Opp 202-755-8493

(188-46-57)

The objective of this RTOP is to study the isotopic and charge composition and energy of galactic and solar cosmic rays. The primary galactic radiation represents the direct penetration of material from the galaxy into the solar system. The study of the nuclear composition and energy of this material provides direct evidence of the stellar processes responsible for the cosmic radiation and information on the interstellar material transmitted by the cosmic radiation. The observation of solar cosmic rays provides information on the abundances of different elements in the sun and information on the solar processes that accelerate energetic particles to their observed energies. The design, construction and test of cosmic ray detectors is the prime activity supported by this RTOP. Solid state detectors, magnetic spectrometers, scintillators, Cerenkov counters and ionization spectrometers are typical instruments developed and tested under the support of this RTOP. Research balloons are employed extensively. Balloon flights are used both to test new instruments and to obtain new scientific information on the properties of cosmic radiation. New instrument concepts are also tested at particle accelerators.

W76-70593 **188-46-56**

Goddard Space Flight Center, Greenbelt, Md.

PARTICLE ASTROPHYSICS

F. B. McDonald 301-982-4801

(188-46-64)

The objective is to measure the energy spectra, charge and isotopic composition of the primary cosmic radiation and of solar cosmic rays. Supporting this objective is the development of new detector systems for the study of the properties of cosmic radiation, and the associated development of theoretical studies related to these experiments. The results will be used in astrophysical considerations concerning the origin, acceleration and propagation of cosmic radiation. Specific goals are enumerated as follows: (1) measurements of the high energy composition of the cosmic radiation, including spectral, charge and isotopic studies from electrons up through the heaviest elements; (2) development of detectors to study the low energy composition of solar and galactic cosmic rays, with the goal of measuring the intensity of cosmic rays at great distances from the sun on deep space missions; and (3) measurements of the positron ratio from 20 MeV to 20 GeV is terminated. Detectors will be designed, constructed and tested in our laboratories. Detector behavior will be explored using particle accelerator beams and other devices. Balloon flights will be carried out both for the purpose of detector development and for obtaining new scientific information. New measurements will be made of the properties of cosmic radiation available for study at balloon altitudes.

W76-70594 **188-46-57**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GAMMA RAY ASTRONOMY
D. P. Burcham 213-354-3028

This describes the JPL program in X- and gamma ray astronomy, part of which is a cooperative effort with UCSD. The primary objective of the program is to observe nuclear gamma ray line spectra from extraterrestrial sources in the .02 to 10 MeV energy range. Such observations could provide important information on nucleosynthesis, galactic history and the physical nature of various celestial objects including cosmic X-ray and gamma ray sources, both constant and transient. Under this program, a high resolution gamma ray spectrometer balloon system will be used in a series of astronomical observations. Additional activities will be the development of advanced concepts in detection techniques, instrumentation and data analysis. The specific objectives for this program for FY-76 are to reduce, analyze, and publish the data from previous balloon flights; conduct two observational balloon flights in the Southern Hemisphere; and continue the development of a gamma-ray burst detector.

W76-70595 **188-46-57**
National Aeronautics and Space Administration, Washington, D.C.
GAMMA RAY ASTRONOMY
Albert G. Opp 202-755-8493
(188-46-59)

The objective of this RTOP is to measure the characteristics of energetic photon emission from celestial sources and to understand the physical process responsible for the emissions. This RTOP includes photonic radiation from approximately 10 keV in energy upward to as high as can be measured, that is, from hard X-rays to ultra-high energy gamma rays. Several hard X-ray sources have been identified, which have spectra extending into the tens to hundreds of keV. The spectra of discrete sources and the spectra and distribution of the diffuse background will provide information on the physical processes active in stars, galaxies and interstellar space. Gamma ray photons result from a number of physical processes. These processes can furnish information on the synthesis and distribution of elements in the universe, on the magnetoplasma environment of a star, on the condensation and interaction of interstellar material with radiation, as well as other astrophysically important parameters. Gamma rays, which are undeflected by magnetic fields, travel directly from their sources, and anisotropies in the direction of arrival of the photons gives information on the location of the gamma ray sources.

W76-70596 **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY ASTRONOMY
C. E. Fichtel 301-982-6281

The technical objective is to develop the most appropriate detector systems for the observation of the astrophysical sources of very energetic photons. The approach has been divided into several different parts. The first approach to the general problem of gamma ray astronomy was the development of a large telescope using digitized spark chambers to be tested on high-altitude balloons and then flown on satellites. Other approaches to detector systems are now being pursued both for the high-energy gamma rays and intermediate gamma ray studies. A medium-energy gamma ray detector has been designed and built. A unique feature of this system is its high time resolution which will permit the tagging of several gamma rays during a short (microseconds) pulse as might be expected from a supernova outburst. Additionally, the theory of shaped scintillation detectors for measurement of medium energy gamma rays on small satellites is being studied, and design work of a detector system will begin in the near future. Improvements in the particle chamber systems are continuing, and methods for accurate timing are being developed for a search for discrete source emission of gamma rays at pulsar periodicities. Special attention in the particle chamber research is now being directed at designing and building a low cost chamber of significantly larger size. At the same time several different approaches are being explored to improve angular resolution, especially through better positional accuracy, as well as sensitivity for future gamma ray telescopes. A factor of two improvement in positional accuracy in both dimensions has already been achieved and several approaches for further significant improvements are currently under study. These developments should provide the improvements in sensitivity and angular accuracy which are critical to the future advancement of gamma ray astronomy.

W76-70597 **188-46-58**
Goddard Space Flight Center, Greenbelt, Md.
LOW ENERGY GAMMA RAY ASTRONOMY
T. L. Cline 301-982-4375

The technical objective of this new research program is to carry out extensive studies in astronomy in the 0.1 to 10-MeV region, intermediate between the traditional X-ray and gamma-ray domains. Spectroscopy, as a basic element in this program is central to its success, since high-resolution energy determination is the tool that will make possible the scientific advances in this window of the electromagnetic spectrum where background problems have always predominated. The study of the 0.1 to 10 MeV gamma ray spectrum is critical in high-energy astrophysics, since this energy region contains many important monochromatic lines and spectral features which are the signatures of basic astrophysical processes. Nuclear gamma-ray lines in particular are expected in great profusion in this energy interval. Identifications of nuclear and isotopic species are uniquely possible with the detection of these characteristic gamma-ray lines. Among these, depending on the process involved, are the 2.23 MeV deuteron line, the 4.43 MeV carbon-12 line, the 6.14-MeV oxygen-16 and 6.33 MeV nitrogen-15 lines, some of which have been observed in solar flares. Additional possibilities are the 0.43 MeV beryllium-7 and 0.478 MeV lithium-7 lines, and the 0.845 MeV and 1.24 MeV iron-56 lines, not to mention the 0.511 MeV positron line, a unique feature not necessarily the product of a specifically nuclear reaction. Many theoretical treatises have been written predicting measureable fluxes of the various nuclear gamma-ray lines from astrophysical sources, including supernovae and novae and their remnants, X-ray emitters, and diffuse regions, including the galactic plane and center. For example, following a nearby supernova event (which itself may turn out to be detectable as a brief but intense X- and gamma-ray emitter), the several-week decay period of the light curve predicts a variety of fractional MeV gamma-ray lines. These, unlike the flare or burst-type transients, exist for a----

W76-70598 **188-46-59**
National Aeronautics and Space Administration, Washington, D.C.
X-RAY ASTRONOMY
Albert G. Opp 202-755-8493
(188-46-56)

The objective is to investigate and understand the nature of sources of X-ray emission. The number of sources detected has been increasing by virtue of the active observational program being conducted with balloons, rockets, and satellites. As experimental techniques have been refined, a number of point sources have been identified with unusual optical objects both galactic and extragalactic in origin. In addition, X-ray variability of different characteristic forms has been found; some sources are analogous to the radio and optical pulsars. The general cosmic X-ray background, as well as the point sources need further study in order to elucidate the emission mechanism and the cosmological significance of these objects. Specific objectives are the detection of additional sources, spatial mapping of the background; accurate positional determination and correlation with optically identifiable objects. These objectives are met by supporting laboratory studies, flight programs, and theoretical work. Research and development of advanced detectors, shielding systems, and focussing optical systems are being conducted. Data processing methods are being refined.

W76-70599 **188-46-59**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY ASTRONOMY
Elihu A. Boldt 301-982-5853

Celestial X-ray sources have introduced us to rich new aspects

of astronomy ranging from the millisecond bursts of hard X-rays coming from the innermost orbits of matter falling into a black-hole to the broadened K lines emitted by subrelativistic cosmic ray iron nuclei ejected into the interstellar gas from recent supernovae such as Cas A. The combination of large sensitive area, low detector background, high temporal resolution and non-dispersive spectroscopy over a broad bandwidth has been our approach in discovering and exploring these phenomena. The power of this approach is being well demonstrated. Extending it with improved spectral resolution and broad-band imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise ionization counters of optimum resolution, large area X-ray concentrators, imaging counters and associated scatter-hole camera configurations.

W76-70600 **188-46-64**
Marshall Space Flight Center, Huntsville, Ala.
COSMIC RAY AND GAMMA RAY ASTRONOMY INVESTIGATIONS
T. A. Parnell 205-453-5130

The objective is to develop instrumentation, perform theoretical calculations and develop data analysis techniques for measurements on high Z cosmic rays and for gamma rays between 0.1 and 10 MeV. To test the instrumentation and techniques for shuttle era experiments by performing observations of the cosmic ray and gamma ray flux on balloons. This work will include the following tasks: using detectors and techniques already developed, a large-area (25 sg m) multi dE/dx Cerenkov counter system will be flown on a balloon to perform a high resolution measurement of the individual elements from Z = 6 thru 28. A study will be made to extend this class of detector system to very large area for use in shuttle era experiments for high charge resolution measurments in the Z greater than 28 region. Theoretical work will continue on the application of Mott cross sections to detector response for High Z. A high resolution (GeLi) gamma-ray detector with a low loss dewar and large area NaI detectors will be assembled into an instrument for observation of gamma ray lines from the galactic center region, and to search for small gamma ray bursts. This instrument will include a novel data system now under development for use on long-duration (super-pressure) balloons. Calculations and experiments will continue on gamma ray background due to neutron and proton activation.

W76-70601 **188-46-64**
Goddard Space Flight Center, Greenbelt, Md.
SHUTTLE DEFINITION STUDIES FOR HIGH ENERGY ASTROPHYSICS
F. B. McDonald 301-982-4801
(188-46-56)

The objective of this program is to develop a variety of new detector systems for high energy astrophysics research, including cosmic ray, X-ray and gamma ray astronomy. Meaningful new experiments in these fields presently require the development of several new devices, incorporating new improvements in energy, charge and isotope resolution, in temporal resolution and directional resolution, and utilizing very large payloads of great size and weight, capable of orbit with the shuttle. These include the cosmic-ray composition and energy spectrometers. The technical objective is to measure the energy distribution and the charge and mass composition of the several components of the primary cosmic radiation. These components include both electrons and nuclei from hydrogen to iron, lead, uranium, and beyond. Beyond 10 to the 12th power eV, no information is presently available, primarily because particles in this range are very rare. The spectra fall steeply with increasing energy requiring large area detectors and long exposure times. This large exposure must be obtained while maintaining the resolution of much smaller detectors. Energy measurements in this highly relativistic range are currently being done using ionization spectrometers and gas Cerenkov detectors. Development of new techniques such as transition radiation detectors and magnetic spectrometers, will be required for some measurements. The properties of charge measuring devices, direction detecting devices, and energy spectrometers will be calibrated on the ground and studied at balloon altitudes. These detectors are being developed for shuttle missions which will provide the essential exposure time and background free environment.

W76-70602 **188-48-51**
Marshall Space Flight Center, Huntsville, Ala.
INTERDISCIPLINARY SPACE SCIENCE RESEARCH
E. Stuhlinger 205-453-3033

The objective is to conduct space research in various scientific and technical disciplines with a capability of directing quick reaction efforts toward significant problems or promising areas of research and with the overall purpose of enhancing in-house scientific capabilities of the MSFC. Such research is related to the physics and astronomy programs of NASA. Under the direction of the Associate Director for Science, Dr. Ernst Stuhlinger, research is initiated in scientific and technical areas which influence the scientific missions of the center. Research projects are selected that, within available resources, contribute significantly to in-house scientific capabilities and state-of-the-art advancement. These projects are then funded from the Interdisciplinary Space Science Research discretionary funds.

W76-70603 **188-48-52**
Goddard Space Flight Center, Greenbelt, Md.
BASIC THEORETICAL RESEARCH
A. Temkin 301-982-4091

The objective is to develop techniques for the solution of basic (prototype) atomic collision problems involved in processes occurring in planetary and stellar atmospheres and in other plasmas: also for collision processes that may be used as diagnostic tools in atmospheres. Specific work implementing the above objective falls into the following general categories: (1) study of electron impact ionization, (2) development of techniques and calculations of autoionization states of atomic systems, (3) calculation of electron molecule scattering techniques, (4) charge exchange of iron nuclei with cosmic gases, (5) study of electron-atom scattering methods, (6) investigation of electron-positron annihilation in solar flares, (7) development of a calculational program of electron-ion impact excitation, and (8) precision calculation of H(+)2 transition frequencies.

W76-70604 **188-78-51**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: SIGNAL AND DATA PROCESSING ELECTRONICS; SOLID STATE DETECTORS
James H. Trainor 301-982-6282

The technical objectives of this research project are to develop and test new on-board signal handling, data processing, storage, computing and auxiliary electronics circuitry for use in energetic particle and astrophysics experiments on spacecraft, rockets, balloons, etc., as well as special test and analysis equipment applicable also for both ground and shuttle usage. The growing complexity of experiments and the often corresponding increase in the volume of data obtained have made signal handling, data processing and data transmission capability limiting factors. To reduce the transmission of unnecessary data, it is necessary to increase the experiment's on-board signal handling and data processing capability. This program is approached through (1) the investigation and development of new techniques for signal shaping and handling, data processing and auxillary circuitry, and (2) the modification of existing techniques by the application of advanced technology and materials including MOS/LSI technology, thick film techniques, and multiple chip techniques. Special techniques must also be devised in order to accurately and efficiently evaluate and test the flight systems at low cost. The use of micro-processors and minicomputers is being pursued both for ground testing and in-flight data systems. The technical objective of the research project is to conduct a program of research and development, and device test and evaluation in the field of silicon nuclear radiation detectors with emphasis on (1) the improvement of detector technology; (2) the understanding of the radiation damage effects on device operation and lifetime; (3) the understanding of the effects on these detectors of chemicals commonly used near or on spacecraft; (4) to establish the technology for the fabrication of specialized devices not available

from industry; and (5) to continue the pragmatic life testing now underway.

W76-70605 **188-78-51**
Marshall Space Flight Center, Huntsville, Ala.
LOW GRAVITY SUPERFLUID HELIUM ADVANCED TECHNOLOGY DEVELOPMENT
Richard A. Potter 205-453-3431

Several experiments are currently being developed which will require a low temperature environment for their proper operation in space. Superfluid helium will undoubtedly be used for many of these applications. Immediate application to experiments is to be found in cosmic ray, relativity and infrared astronomy. The purpose of this RTOP is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown into space. The properties of superfluid helium in this near zero gravity environment will be assessed and methods will be investigated whereby problem areas may be resolved and/or controlled. Low gravity aircraft and rocket flights will be conducted to permit more realistic design on helium dewars.

W76-70606 **188-78-51**
National Aeronautics and Space Administration, Washington, D.C.
ADVANCE TECHNOLOGICAL DEVELOPMENT, GENERAL; CRYOGENICS
M. J. Aucremanne 202-755-3676

Physics and astronomy experiments are being developed which will require a low temperature environment for their proper operation in space. Superfluid helium will undoubtedly be used for many of these applications. The purpose of this work is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown in space. Properties of superfluid helium and other cryogens for application in IR astronomy, cosmic ray physics and relativity will be assessed and methods to deal with problems will be developed.

W76-70607 **188-78-56**
Goddard Inst. for Space Studies, New York.
MILLIMETER WAVE AND FAR-INFRARED DETECTORS
A. R. Kerr 212-678-5562

Coherent detectors similar in principle to those available at radio frequencies will be developed for the far infrared, and research will be conducted to advance detector theory and technology at millimeter wavelengths. In the virtually unexplored spectral band from 500 to 1500 microns it is expected that sensitivities many orders of magnitude greater than those presently available from thermal detectors (bolometers) can be obtained. The scientific purpose is to lay the foundation for spectral line observations of astronomical objects and the atmospheres of the earth and planets. A prime objective is to provide spectral line receivers for the study of interstellar molecules with the large uncooled telescope of the space shuttle, and radiometers for the upcoming generation of meteorological satellites. A 1.7 mm wavelength detector is being developed under this RTOP for the Microwave Limb Sounder (RTOP #176-31-53) which is planned for an early flight of the space shuttle, and a low-noise 2.6 mm detector is being constructed for use on the Columbia-GISS Sky Survey Telescope. Quasi-optical guiding techniques will be used, together with new microscopic antenna-like resonant structures produced using photolithographic techniques. Existing nonlinear elements - Schottky-Barrier diodes and Josephson junctions - are potentially capable of performing the required electrical functions, but their physical configurations must be revised to permit their integration into microscopic circuit structures. Concurrently with this work a detailed study is being made of millimeter wavelength mixers - which are still poorly understood - to determine the optimum embedding structures for low-noise operation, and to investigate the anomalous noise observed in these devices.

W76-70608 **188-78-56**
National Aeronautics and Space Administration, Washington, D.C.
INSTRUMENTATION TECHNOLOGY - IMAGE TUBE AND DETECTOR DEVELOPMENT
M. J. Aucremanne 202-755-3676

Development of large space telescopes is fundamental to the objectives of the Astronomy Research Program. It is essential that normal incidence image forming systems operating with maximum spatial and spectral resolution in the IR, visible, and ultraviolet regions be evolved. These instruments will be required to detect and present astronomical data in extreme fidelity. In order to accomplish this it will be necessary to develop a series of instruments that both accomplish their scientific objectives and at the same time provide technological data to permit a burgeoning capability. In order to fully utilize such advanced telescopes it will be necessary to concurrently develop suitable electronic image sensing system.

W76-70609 **188-78-60**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED MISSION STUDIES FOR EXPLORER PROGRAMS
Paul Butler 301-982-4503

The objective is to perform studies and necessary research in support of continuing advanced mission studies for Explorer class missions as defined in NASA AO no.6 and AO no.7. AO no.6 solicits participation in the scientific teams that will define missions for Explorer spacecraft launched by either Scout or Delta vehicles or space shuttle. AO no. 7 solicits proposals for the complete definition of individual scientific missions for Explorer class spacecraft launched by Scout only. The approach is to support assigned studies and tasks related to the above AO's involving NASA, the U.S. scientific community and the international scientific community. Support will be provided by conducting required study and research effort either in-house, out-of-house, or in combination. Support is being provided now in evaluation of available proposals. This will continue for future proposals. Assistance will be further provided in support of the scientific mission definition teams appointed as a result of the AO activities.

W76-70610 **188-78-60**
Langley Research Center, Langley Station, Va.
SCIENTIFIC DEFINITION STUDY FOR AIR DENSITY EXPLORERS - 1980 (NEUTRAL DYNAMICS EXPLORERS)
E. S. Love 804-827-2893
(385-36-01)

The objective is a scientific definition study (in response to AO no. 7) of the next generation Air Density Explorer experiment which will use a complementary set of drag and mass spectrometer experiments to study the structure, composition, temperature, and dynamics of the thermosphere and exosphere. The experiment will include neutral and ion mass spectrometers, as well as a drag-free proof mass to allow the detection of accelerations orders of magnitude smaller than flight-proven accelerometers. The measurements from these Neutral Dynamics Explorers will be compared to those of ionic constituents from the Electrodynamic Explorer type experiment (mentioned in AO no. 6).

W76-70611 **188-78-60**
National Aeronautics and Space Administration, Washington, D.C.
ADVANCED MISSION STUDIES
M. J. Aucremanne 202-755-3676

The objective of the Advanced Mission Studies is to initiate studies both in-house and on contract for the Explorer Series and for the disciplines represented in Physics and Astronomy Programs. This RTOP will permit studies to be initiated for those disciplines outlined in the recent announcement of flight opportunities. The need for observations in the disciplines of physics and astronomy has been expressed by the National Academy of Sciences (NAS). Endorsement of the Explorer Series has been provided by the NAS in their summer studies and by others in the scientific community. The purpose of this RTOP is to expedite preliminary and conceptual studies by the appropriate field centers. If OSS is to continue to meet the goals of this agency, then it is imperative that we initiate the studies required to meet our scientific commitments to the nation. The technical

objectives of the planned effort include support activities in definition studies, the review of prior projects to ascertain whether existing subsystems, systems and hardware can be used in a minimum cost approach to designing the basic spacecraft, and the resources required to conduct the missions.

W76-70612 **188-78-60**
Marshall Space Flight Center, Huntsville, Ala.
SHUTTLE LAUNCHED HIGH ENERGY ASTROPHYSICS SPACECRAFT
Joseph R. Dabbs 205-453-2817

Shuttle launched free flying spacecraft instrumented for High Energy Astrophysics are planned for the time period of 1980's onward. While it is impossible to predict the instruments and experiments which will have priority in that time frame, it is reasonable to select several representative experiment complements and associated mission requirements as inputs for evaluation of spacecraft requirements. The mix of science requirements and instruments will be furnished by the Physics and Astronomy Programs Office. Additional information is available from the 1973 High Energy Astrophysics Working Group final report and the 1973 Woods Hole Group. These missions will be examined with regard to spacecraft commonality and feasibility in a preliminary in-house study. The follow-on contracted study will do a detailed technical analysis.

Planetary Biology

W76-70613 **192-55-61**
Ames Research Center, Moffett Field, Calif.
CHEMICAL EVOLUTION
H. P. Klein 415-965-5094
(192-55-62; 192-55-67)

Chemical evolution encompasses the study of the evolutionary path of carbon and its compounds from the primal fireball, through interstellar dust clouds, to formation of galaxies, solar systems, and planets, to the beginnings of life on the earth. In the laboratory, the syntheses of organic compounds related to terrestrial biochemicals are explored in experiments which simulate the putative environments of interstellar dust clouds, cooling solar nebulae and primordial and extant planetary atmospheres and surfaces. The study is relevant to understanding the prebiological chemistry of the solar system which led in the case of earth to the formation of organic compounds and the origin of life, but which on extraterrestrial bodies and environments may have taken divergent paths. The study provides an experimental basis for the hypothesis that the origin of life on earth, and possibly elsewhere, was preceded by a period of organic chemical evolution in which simple compounds containing the organogenic elements C, N, O, S, P, H were converted by abiotic processes into the complex organic molecules which are direct precursors of the macromolecules essential to life.

W76-70614 **192-55-62**
Ames Research Center, Moffett Field, Calif.
ORGANIC GEOCHEMISTRY
H. P. Klein 415-965-5094
(192-55-61)

The principles and practices of organic geochemistry can be applied in any cosmo-chemical investigation wherein a solid matrix is studied for the presence of organic matter and its characterization. Thus, geological materials from earth and extra-terrestrial samples such as meteorites, lunar materials, and future samples returned from planets are objects of study. Organic geochemistry seeks to elucidate the occurrence, nature, and distribution of organic compounds in meteorites and in terrestrial substances such as contemporary environments, recent and ancient sediments (including Precambrian rocks), and fossils. The methods and results of these studies can be applied to the interpretation of the significance of organic substances in terrestrial and extraterrestrial materials. By using the earth and its geochemical processes as a model, information about the influence of extraterrestrial processes on organic matter can be better understood. Highly refined analytical techniques are developed and used in organic geochemistry to separate organic compounds from mineral matrices. These compounds form the basis for understanding geochemical processes including diagenesis. From these studies chemical criteria developed in chemical evolution experiments to distinguish between organic matter of biological and nonbiological origin can be tested and evaluated using geological samples. These criteria are essential for understanding the mode of origin of extraterrestrial organic materials.

W76-70615 **192-55-63**
Ames Research Center, Moffett Field, Calif.
PLANETARY SOIL MICROBIOLOGY
H. P. Klein 415-965-5094
(192-55-66)

Studies are being performed to better implement the development of techniques for the detection of extraterrestrial life for missions utilizing in situ instrumentation in or on soils, or in soil samples returned from planetary exploration missions. This work includes the science required to elucidate and/or facilitate the amplification of biology or biological changes in the gas, liquid or solid phases.

W76-70616 **192-55-64**
Ames Research Center, Moffett Field, Calif.
BIOLOGICAL ADAPTATION TO EXTREME ENVIRONMENTS
H. P. Klein 415-965-5094
(192-55-67)

The objective of this RTOP is to study terrestrial microorganisms which have adapted to life under environmental extremes, as (1) models for organisms which may be found on other planets, (2) possible terrestrial contaminants of other planets, and (3) examples or organisms which may be present in samples returned from Mars in the future. There are terrestrial microorganisms which live in conditions of high and low temperatures, low humidity, high radiation flux, acidity, alkalinity, and salinity; all environments found on one or more of the other planets. The enzymes, structural components, and genetic systems of these organisms are being studied to determine how they have been modified during adaptation to such conditions. The information will suggest whether it is reasonable to expect that life forms resembling terrestrial life could have evolved on a particular planet, and what characteristics might be present in those forms. In addition, there will be information important to the questions of forward contamination of another planet, and back contamination to earth.

W76-70617 **192-55-65**
Ames Research Center, Moffett Field, Calif.
BIOINSTRUMENTATION
H. P. Klein 415-965-5094

The broad objectives of this effort are to develop instrumentation and techniques for the detection and characterization of life on other planets. The primary emphasis of the program is directed toward the planet Mars, but consideration will be given to application of the instrumentation to other planets. The work projects involve the continued development of operational breadboard models of the Unified Biology Experiment and the Wet-Chemical Amino Acid Analyzer, which are being developed as candidate post-Viking experiments. Development of operational breadboards and prototypes for the Unified Biology and the Wet Chemistry Analyzer experiments will be continued with emphasis on test programs to insure that the current designs will adequately perform the scientific goals of the experiments and to identify engineering problems which will require further design and development efforts.

W76-70618 **192-55-66**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENVIRONMENTS
H. P. Klein 415-965-5094
(192-55-63)

Scientifically justifiable methods of analyzing biologically important parameters are being studied for instrumental implementation in order to assess the extent of a planet's biological

habitability based on the planet's atmosphere and water history, and for selecting biologically enriched areas based on water availability and atmospheric characteristics.

W76-70619 **192-55-67**
Ames Research Center, Moffett Field, Calif.
ORIGIN OF LIFE
H. P. Klein 415-965-5094
(192-55-64; 192-55-61)

The objectives are to advance our understanding of the processes which are critical to the development of the first living systems on the earth, and to suggest how those processes would function on other planets. Studies on the origin of life focus on the production of functional macromolecules, their organization into systems with one or more of the characteristics of living cells, and eventually the appearance of metabolizing, replicating organisms. Information which can be acquired about these processes, and how they led to the appearance of life on earth, can also be applied to consideration of a biota on the other planets. Laboratory studies will include: assessment of ultraviolet light as a primitive energy source as well as degradative force; the role of changing atmospheric constituents (e.g., the appearance of oxygen) on the evolution of primitive organisms; the origin and evolution of catalytic systems; and the development of information transfer systems required for cell replication.

Planetary Quarantine

W76-70620 **193-58-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY QUARANTINE ADVANCED STUDIES
C. W. Craven 213-354-5322

Planning and analytical studies will be carried out which support the development of planetary quarantine requirements together with basic analytical techniques for their effective implementation in flight programs. Potential contaminating events of future missions will be evaluated. Specifically, these studies will include: (1) evaluation of the impact of planetary quarantine constraints on Jupiter-Uranus flyby missions, as well as probe missions to the outer planets; and (2) determining the effects of the natural space environment on the survival of microorganisms. These studies are conducted to identify and better understand the planetary quarantine constraints applicable to various planned missions. This, in turn, will permit the development of procedures and methodology to reliably satisfy such constraints. This RTOP also provides for Planetary Quarantine Project Office functions (as directed by the NASA Headquarters Program Office). These include program planning, definition of resource requirements, technical monitoring of research work, solicitation and evaluation of technical proposals, and establishment of research contracts. In addition, a JPL detailee, located at NASA Headquarters, is provided to support the Planetary Quarantine Program Office on a day-to-day basis and to provide support in budget and funding analyses.

W76-70621 **193-58-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROBIAL ANALYSIS
C. W. Craven 213-354-5322

The objective of this RTOP is to develop methodology and data for quantitatively estimating the level of contamination resulting from the transfer of contaminants between various elements of spacecraft hardware. This involves the development of analytical algorithms as well as the generation of empirical data needed to exercise the model. Physically significant parameters and processes will be analytically modeled and experimentally verified, where possible, to obtain confidence in the results. The approach will be to: (1) perform experimental tests (in existing JPL facilities) to obtain parametric data relative to the various physical phenomena being modeled. These data will be used to refine and verify the analytical recontamination models; and (2) to perform sensitivity analyses to assess the impact on recontamination of operating missions in various modes. In addition, contracted studies are planned which will examine: (1) the nonlinearity of the probability of growth for Mars; and (2) the technical propriety for inflight revision of the probability of planetary contamination.

W76-70622 **193-58-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CONTAMINATION CONTROL
C. W. Craven 213-354-5322

The objective of this RTOP is to develop methodology and procedures for quantitatively estimating and reducing microbial contamination on an assembled spacecraft just prior to encapsulation or terminal sterilization. This technology is needed for: (1) determining a minimum acceptable sterilization process such as may be required for a planetary lander or probe; and (2) reducing microbial contamination on spacecraft not requiring sterilization so that planetary contamination probabilities may be reduced. This RTOP provides for activities of the Planetary Quarantine Laboratory at the Air Force Eastern Test Range. This laboratory's research is directed at improving and evaluating microbial sampling techniques, microorganism enumeration estimates, sterilization procedures and rapid identification of microorganisms associated with spacecraft and their environments. The RTOP also covers studies of the interaction between currently used cleaning and decontamination procedures and the operational constraints that may prevail when planetary spacecraft are launched by space shuttle.

W76-70623 **193-58-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY BACK CONTAMINATION
C. W. Craven 213-354-5322

The primary objective of this RTOP is to study the quarantine implications of introducing extra-terrestrial materials into the earth's biosphere. Such materials may be in the form of samples purposely being returned to earth from extra-terrestrial sites or may exist as 'contaminants' on vehicles returned to earth after having encountered extra-terrestrial targets. The secondary objective of this RTOP is to study methods for: (1) reducing or eliminating extra-terrestrial contamination on earth return vehicles prior to their entry into earth's biosphere; and (2) manipulating and processing returned extra-terrestrial samples in order to make determinations relative to the need for their quarantine or the risks involved in their release therefrom. Basic questions involving the definition and detection of life from a quarantine viewpoint will be addressed. Operational protocol and problems associated with the use of the Lunar Receiving Laboratory will form a framework for the initial part of these studies.

Lunar Science

W76-70624 **195-20-01**
National Aeronautics and Space Administration, Washington, D.C.
EARTH BASED OBSERVATIONS
F. I. Roberson 202-755-1602

Continued study of the lunar surface using earth-based instruments. Studies of broadband reflection spectroscopy is used to determine the chemical and mineralogical composition of the lunar surface. Study of the moon in terms of composition, surface processes, and retional geology using data from telescopic spectral reflectivity. Using telescopic measurements of minute color differences, studies will be on separating lunar maria into chemical stratigraphic units and dating these units.

W76-70625 **195-20-02**
National Aeronautics and Space Administration, Washington, D.C.
THEORETICAL STUDIES
F. I. Roberson 202-755-1602

Development of scientific concepts about the composition, structure, stratigraphy, origin, and history of the moon and its constituent features requires an iterative process of data

acquisition, synthesis, and theory. The evolving theoretical models of the moon have been constantly refined through testing and modification in this series of studies. Major areas of research include temperature-pressure studies, cosmogenesis, seismology, electrical conductivity, geologic mapping, interactive of lunar materials with energetic particles, and thermodynamics of lunar processes.

W76-70626 **195-20-03**
National Aeronautics and Space Administration, Washington, D.C.
LABORATORY SIMULATION
F. I. Roberson 202-755-1602

To study the moon by experimentation in the laboratory. This includes study of the lunar surface by laboratory observations the effect of various types of solar radiation of silicate glass. Study through models, the lunar interior structure and evolution as constrained by the physical and chemical properties of the same minerals found on the moon. Study the shock effects, in the laboratory, of rock-forming minerals and the synthetic materials under a wide range of temperatures and pressures. Study shock metamorphism effects and cratering phenomena to impact parameters of meteorids using the laboratory facilities.

W76-70627 **195-20-04**
National Aeronautics and Space Administration, Washington, D.C.
EXTRATERRESTRIAL MATERIALS
F. I. Roberson 202-755-1602

The objectives of extraterrestrial materials program are to improve and extend scientific and technical knowledge of meteorites in order to increase our understanding of the composition and history of the solar system, give detailed information on present and past conditions of cosmic radiation in interplanetary space (space probes), and supplement studies of the chemical, physical, and geological properties of the lunar samples. The wide variety of experimental techniques available for meteorite study, including measurements in crystallography, mineralogy, radioactivity, particle tracks, chemical and isotopic composition, etc. - serve to give us detailed information on the origin, age, and history of these extraterrestrial objects.

W76-70628 **195-20-05**
National Aeronautics and Space Administration, Washington, D.C.
ANALOGUE STUDIES
F. I. Roberson 202-755-1602

Studies of terrestrial features that have been formed by similar processes to those that are believed to have shaped the moon's surface provide the data needed to interpret lunar history. The type of features being extensively studied are: terrestrial meteorite impact structures, terresterial volcanoes, mass waste erosion, lava ridges, ash flows and ejecta flows. These are the type of features that appear to be dominant on the lunar surface.

W76-70629 **195-20-06**
National Aeronautics and Space Administration, Washington, D.C.
SCIENCE EXPERIMENT CONCEPTS
F. I. Roberson 202-755-1602

Experimental concepts are conceived, developed, and demonstrated that pertain to the lunar orbit and surface which require perfection of techniques of data reduction and analysis, and interpretation as well as investigation of concepts, instruments, and hardware including testing and calibration. These experiments emphasize goephysics and geochemistry.

W76-70630 **195-21-02**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF THE MOON AND METEORITE PARENT BODIES
D. R. Chapman 415-965-5065

The objective is to understand the origin, evolution, structure, and present state of the moon by means of theoretical investigations which incorporate the results of lunar, spacecraft, and groundbased experiments. To achieve this objective theoretical and experimental knowledge of physical processes are used, together with astronomical and geological data, to construct and analyze mathematical models of lunar processes and structure. The results of these calculations are interpreted in terms of such topics as: initial thermal state, composition, material properties, and thermal history of the moon, the interpretation of rare gas studies of meteorites and lunar samples, the cratering history of the lunar surface, and the dynamics of tidal fission and subsequent impact of lunar orbiting bodies.

W76-70631 **195-21-03**
Ames Research Center, Moffett Field, Calif.
IMPACT CRATERING IN GEOLOGIC MATERIALS
D. R. Chapman 415-965-5065
(383-21-02)

The objective is to study scaling laws and trajectories of debris ejected from impact craters formed in various targets to understand impact crater formation and emplacement of crater deposits on various planetary surfaces and to study the formation of doublet craters and their ejecta patterns. To achieve this objective the Ames Vertical Gun Impact Range will be used. Gravitative effects are evaluated by cratering dropping noncohesive sand targets where each drop has a selected constant acceleration and where the cratering is recorded on 35 mm stereo movie film. Multicolored, patterned sand targets are used to establish points of origin and deposition of ejecta. A plate dissector will be used with a high speed camera to record trajectories and velocities of fragments ejected throughout crater growth. Special layered targets will be impacted to study the origin of lunar and terrestrial impact melts, and techniques of achieving simultaneous impact developed earlier will be used to model conditions of origin of selected lunar crater complexes suspected of having such an origin.

W76-70632 **195-21-04**
Ames Research Center, Moffett Field, Calif.
CHEMICAL AND ISOTOPIC STUDIES OF METEORITES AND ABLATION PRODUCTS
D. R. Chapman 415-965-5065
(385-45-01; 188-45-53)

The objective is to utilize various analytical techniques to (1) characterize formation and post-formational histories of carbonaceous chondrites and basaltic achondrites; (2) to determine the feasibility forming iron meteorites from a cold beginning; and (3) characterize the reaction and fractionation products of meteor ablation to develop criteria for identifying ablated debris in the terrestrial environment. To achieve this objective analyses will include the following techniques: electron microprobe, microscopy, ion microprobe, heating and phase equilibria, X-ray diffraction, X-ray flourescence and scanning electron microscopy. Most carbonaceous chondrite are breccias that formed in a water vapor environment. Ongoing textural-mineralogical studies have resulted in significant progress. Concentrations of volatile and nonvolatile elements and various isotopic ratios in different constituent phases now must be determined to test and/or refine models of their origin. Basaltic achondrite breccias appear to have formed on the surface(s) of the parent body(ies). Detailed studies of component lithic and mineral fragments will provide information on rocks exposed at the parent body surface during formation and thus evidence of its state of differentiation and history. Ongoing experiments are being used to examine the possibility of formation of iron meteorites from parent bodies with low temperature origins. Fusion crusts and ablated products of artifically ablated materials are being studied and compared to natural materials to develop criteria necessary for the recognition of such debris in the stratosphere, in sediments and in glacial ice.

W76-70633 **195-22-02**
Goddard Space Flight Center, Greenbelt, Md.
THEORETICAL STUDIES
J. A. O'Keefe 301-982-4445

This work consists of diverse theoretical studies on the structure and history of the moon. Included are studies of the mechanics of the earth-moon system during breakup; studies of the loss of volatile material in the early history of the moon;

studies of the deficiency of nickel and precious metals in the moon's surface; and studies of tektites, regarded as possible natural lunar samples. Work so far suggests that a number of conventional ideas about the moon are less securely founded than is usually assumed, including the mechanics of cratering, especially by impact.

W76-70634 **195-22-03**
Goddard Space Flight Center, Greenbelt, Md.
PHYSICAL AND CHEMICAL STUDIES OF SOLAR SYSTEM SOLIDS
J. A. Philpotts 301-982-5206
(195-22-04; 195-22-06; 383-22-04)

The objective is to characterize the phase reactions and associated magnetic properties in materials which simulate meteorites and planetary surfaces and which are affected by shock impact and thermal processes in variable FO sub 2 conditions, and to relate this information to integrated syntheses and interpretations of available meteorite and planetary surface data in order to develop process-response models to provide a basis for understanding planetary magnetism. Laboratory experiments utilizing man made alloys and other simulations which have been subjected to known dynamic and thermal histories will be conducted concurrently with experiments on meteoritic material whose history must be deciphered. The manner in which dynamic and thermal processes affect spectral reflectance will be recorded as part of the systematic program in order to relate magnetism to telescope reflectivity curves and other remote sensing techniques. Newly defined and established remanence mechanisms for metals will be systematically evaluated, and the nature of remanence acquisition by controlled, dynamic, and thermal processes as a function of field dependence will be explained. Thermal reduction in low FO sub 2 will be evaluated along with synthesis and characterzation of specimens which will help to understand lunar rock genesis and in particular the composition of coexistent metal.

W76-70635 **195-22-04**
Goddard Space Flight Center, Greenbelt, Md.
GEOCHEMISTRY AND MAGNETISM OF EXTRATERRESTRIAL MATERIALS
J. A. Philpotts 301-982-5206
(195-22-03; 195-22-06; 383-22-04)

The objective is to study the nature and evolution of condensed matter in the solar system. Laboratory determinations will be made of major and trace element abundances, mineralogy and petrology, radiometric ages, isotopic compositions, magnetic properties, reflectivities, and radioactivities. Meteorites will be the prime samples studied.

W76-70636 **195-22-05**
Goddard Space Flight Center, Greenbelt, Md.
TERRESTRIAL ANALOGUE STUDY OF METEORITE IMPACT CRATERS
J. A. Philpotts 301-982-5206
(195-22-03; 195-22-04; 383-22-04)

The objective is to understand the effects of the meteorite impact process through study of the nature of terrestrial impact craters. Particular attention will be paid to the systematics of the radiometric dating techniques K-Ar and Rb-Sr, including the conditions under which partial or total resetting of apparent ages occurs. Compositional and other affects will also be studied. Terrestrial impactites and unshocked country rocks will be the prime samples studied.

W76-70637 **195-22-06**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEM AND RADIATION EFFECTS STUDIES FOR ORBITAL X-RAY AND GAMMA RAY SPECTROMETER
J. I. Trombka 301-982-5941

The overall objective the development of X-ray and gamma ray spectrometers for remote sensing systems to be included aboard lunar and planetary missions. A number of areas are under study: redesign of the X-ray detector collimator to give a more symmetric response as compared with the Apollo system; development of a new calibration source in terms of the variation of the solar spectrum; the continued study of on-board data processors; the further development of near real-time data processing systems, and finally, the study of the cosmic ray induced activity in X-ray and gamma ray detectors, specifically intrinsic Ge. We also plan further development of the Electron Spectrometer for lunar related research. Problems in solar wind darkening are of specific interests. We plan to use a honeycomb circular collimator with hexagonal shaped holes. This should yield a more symmetric detector response with respect to the surface under observation. Included with the Apollo X-ray spectrometer experiment was a solar monitor to be used to calibrate the spectrum for spectral changes in the sun's emission. This system did not turn out to be too satisfactory. We therefore plan to study an alternate method which utilizes measurement taken with a method depending on the monitoring of the X-ray fluorescence produced in a known composition slab. The slab would be placed so that it would receive direct solar irradiation and the emission would be monitored with a detector similar to that used in measuring the X-ray flux from the planetary surface. The Multiplex Data Accumulator (MDA) now operating in our laboratory would be used to simulate previous on-board data processing systems.

W76-70638 **195-23-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EARTH BASED LUNAR OBSERVATIONS
D. P. Burcham 213-354-3028

We propose: (1) to continue our ground-based observations of the Moon using several techniques; and (2) to accelerate the processing and use of data already obtained with the Silicon Imaging Photometer System (SIPS). This work consists of two tasks which are aimed at investigating (1) the composition and stratigraphy of lunar mare units and (2) the correlation of spectral data with gravity, topography and geochemical information. The Lunar Stratigraphy (SIPS) task uses images acquired by our Silicon Imaging Photometer System to study spectral units in specific lunar regions selected for study of gravity anomalies or standard areas for planned overlap with other data sets. A major part of the task is devoted to exploring data handling and display techniques designed to make optimum use of spectral data for use in synthesis. The facilities of the Image Processing Laboratory allow a wide variety of geometrical corrections (such as Mercator Projection) to be made and a recently acquired GE Image 100 Systems has already been used to greatly speed and improve the classification and display of spectral units identified by 'cluster' analysis. The Infrared Imaging task is a new effort to extend the spectral range of imaging data. This is important as several interesting lunar spectral types (including 'fresh' rock) have greater contrast in this spectral range than at shorter wavelengths. This will be accomplished using the multiplexing masking camera developed under DDF funds, which is now operational with angular resolution of approximately 2 arcsec.

W76-70639 **195-23-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LUNAR THEORETICAL STUDIES
D. P. Burcham 213-354-3028

Lunar physics examines questions about the origin and evolution of the moon applicable to analysis of geophysical, geochemical and geologic data. To the extent that the thermal history of this body can be deciphered, we may expect to understand the origin and evolution of other planetary objects, and especially the earth. The current program will continue study begun last year on recovery of the early near-surface thermal history by analysis of surface deformation under loads inferred (to exist upon it) from the gravity field. Secondly, emphasis will be placed on analysis of tidal deformation of the moon (by earth) using Apollo seismic constraints on interior elastic properties. The Love numbers for models with and without rigid cores will be determined, along with tidal stress and displacements. With these, a distinction may be possible between a rigid but S-wave attenuating core and a non-rigid fluid or partially molten interior. The existence of a moon-wide surface layer of low rigidly (the regolith) is possibly important in masking bulk elastic properties of the interior by measurement of surface deformation

alone. The extent to which this is so will be determined as a natural outcome of the analysis. The elastic data so obtained may be coupled with Love numbers eventually to be determined from the JPL refined analysis of lunar motion using LURE data. The method of analysis for our elastic problem will be that originally employed by Alterman. Jarosch and Pekeris (1959) in their study of free oscillations of the earth. This well-known method requires solution of a system of six simultaneous differential equations in displacements, stresses, and gravitational potential by numerical methods. Software for such a solution has largely been developed here as part of previous studies on deformation of spheres under surface loads.

W76-70640 **195-23-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED EXPERIMENT CONCEPTS
D. P. Burcham 213-354-3028

There are two tasks included in this program. The first task, in the area of Advanced Gamma Ray Spectroscopy, will undertake scientific studies and along lead-time engineering development in anticipation of an opportunity to chemically map the entire lunar surface from a spacecraft placed in a close lunar polar orbit. References points will be the results of the Apollo 15 and 16 gamma ray experiment, and the scientific potential/design requirements of high purity Ge detector instrument. The second task, Particle Track Cosmochronology, will develop new submicroscopic methods for fission track age dating, utilizing the capacity of in situ low-U minerals to record and retain tracks from more labile U-rich phases. These methods should permit us to elimate the problems with fission track ages due to metamictization, partial annealing of tracks in the host phase, very high track densities due to U-rich phases, and questions of authenticity of tracks. Selected terrestial and meteoritic samples will be used in the development. Support for lunar sample application will be sought. We will also continue development of Th mapping methods, including a whole-rock Th method.

W76-70641 **195-35-01**
Goddard Space Flight Center, Greenbelt, Md.
LUNAR POLAR ORBITER SYSTEM DEFINITION
Marius B. Weinreb 301-982-6849
(686-20-00)

The objective of this RTOP is to conduct a System Definition Study to provide management with the necessary information to initiate the Lunar Polar Orbiter Execution Phase. The required information includes: (1) definition of overall systems requirements to carry out the selected experiments; (2) development of and definition of the major interfaces, and (3) development of resources requirements. The approach is to conduct a detailed system definition study including: (1) support of a science working team established to assist in developing basic requirements, preliminary designs and interfaces for the experiments; and (2) definition of total system requirements for critical interfaces, integration and test, and ground operations for all phases of the execution. The major products will be a System Definition Report, a procurement package covering all major contracts, and a Project Plan. Supporting reports will be issued as required.

W76-70642 **195-40-02**
Langley Research Center, Langley Station, Va.
EVALUATION OF TECHNIQUES FOR THE DETERMINATION OF LUNAR AND PLANETARY GRAVITATIONAL FIELDS
E. S. Love 804-827-2893

The objective of this work is to define and evaluate satellite subsystems which would be applicable to an optimum determination of lunar and planetary gravity fields. Due to increased interest by geologists and planetologists in applying the results of gravity field research to internal structure and composition interpretations, continual demands for more exacting information are expected in the future. Throughout the years S/C radio systems have been the primary source of data; however, there exist inherent problems and limitations with radio systems which need to be resolved if further advancements are to continue in gravity field definition. This research will concentrate on the theoretical evaluation of gravitational field sensing devices suitable for lunar and planetary orbiting missions for which implementation technology already exists. Examples of such devices are satellite-to-satellite radio tracking and the gravity gradiometer. Feasibility studies, including as prime bodies, the Moon, Mars, Mercury, and possibly Venus, will be conducted to determine the relative applicability of such devices. Attention will be focused on both the measurement and separability of gravitational effects and the ability of each system to resolve components of the gravity field spectrum. The impact on mission and spacecraft design parameters such as power, weight, and volume will be examined in order to evaluate the merits of each subsystem when compared to the radio system.

Planetary Astronomy

W76-70643 **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED INFRARED ASTRONOMY
V. G. Kunde 301-982-5693

Ground-based measurements of Venus have been obtained with a Michelson interferometer in the 400-500/cm and 750-1200/cm regions with a spectral resolution of 0.2 cm. Evident in the spectral are numerous CO2 molecular absorption lines and several diffuse absortion features in the 850-1200/cm region. Preliminary interpretation of the diffuse features from the observed continuum using homogenous model atmospheres, and considering only absorption, strongly indicates a 75 percent solution H2SO4 for the composition of the clouds of Venus. The scientific objectives of this research is to develop a more complete understanding of the physics of the Venusian atmosphere in the region above 200 mb. This will be accomplished by developing a more physically realistic radiative-transfer model for line formation including scattering in an inhomogenous model atmosphere. With this model additional information may be derived from the observed spectra concerning the physical parameters of the cloud particles and the cloud stratification.

W76-70644 **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
RADIO AND RADAR PLANETARY STUDIES
J. K. Alexander 301-982-5461

The objective of this program is to obtain information on the nature, extent, and dynamical behavior of planetary magnetic fields, trapped radiation belts, and magnetospheres by studying the nonthermal radio emissions from the planets. The major approaches to this investigation are: (1) synoptic observations of Jupiter's decametric radiation via a global network of monitoring instruments; and (2) theoretical analyses of the generation and propagation of nonthermal radiation in a planetary magnetosphere. The Jupiter Monitor Network is providing unique data relative to the rate and stability of the magnetic field rotation and the physics of satellite-plasma interactions in the magnetosphere, and correlative data for fly-by in-situ measurements. Analysis of the radio measurements in the context of new information from the Pioneer 10 and 11 Jupiter encounters may lead to a clearer understanding of the radio emissions and their role in particle-field interactions in the magnetosphere.

W76-70645 **196-41-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED OPTICAL SOLAR SYSTEM ASTRONOMY
S. P. Maran 301-982-4703

This RTOP provides for the operation of a small high altitude observatory for qualitative and quantitative observations and measurements of solar system phenomena. These include imaging research on comets and their interactions with solar radiation and the solar wind, as well as photoelectric photometry and spectroscopy of asteroids, comets, planets and natural satellites of the planets. In addition, if a suitable bright comet appears optical observations will be made with a mobile vidicon facility and radio observations will be made with existing national facilities.

W76-70646 **196-41-54**
Goddard Space Flight Center, Greenbelt, Md.

ADVANCED INFRARED ASTRONOMY AND LABORATORY ASTROPHYSICS

Michael J. Mumma 301-982-6994

Two new infrared spectrometers will be further developed and used for high resolution infrared astronomy and laboratory astrophysics. The first, an infrared heterodyne spectrometer, was assembled in an attempt to search for NH3 in Comet Kohoutek and has been used successfully to detect thermal emission from Mars and the Moon. This instrument has been re-designed, based upon the experience gained in building the first version, and is now being re-built. It will feature a 40-channel, 1 GHz, filter bank and a digital data system for acquiring the heterodyne signal. The improved system will be used to study molecular lines in comets, H II regions, and planetary atmospheres. The second instrument, an infrared parameteric up-converter has been assembled and an upconverted 3.3 m signal was detected. Modifications are now being made which are expected to reduce the NEP to 10-15 watts/Hz1/2, 102 lower than the NEP of the present version. The objective is to have the heterodyne system on-line at an astronomical field site by the end of the year. Laboratory experiments necessary for the proper operation of the spectrometers and/or essential to the proper interpretation of results will also be carried out. These include precise line position measurements, pressure broadening coefficients, and the study of excitation processes. Under a proposed new task, radiometers will be developed for millimeter wavelength observations of several important molecules occurring in planetary atmospheres, particularly H2O, O2, and O3. High frequency mixers and frequency lock loops will be developed at 60, 120, and 180 GHz. This task will initially use the spectral line receiver developed under the infrared heterodyne program.

W76-70647 **196-41-67**

Ames Research Center, Moffett Field, Calif.

PLANETARY ASTRONOMY AND SUPPORTING LABORATORY RESEARCH

D. R. Chapman 415-965-5065

The abundance, temperature, and pressure of certain constituents of planetary atmospheres can be determined by spectroscopic observations from ground-based and from airborne observatories. Such data are necessary for the preparation of model atmospheres that are needed to evaluate the possibilities of life on the planets and to design systems for exploratory missions. The objectives of this work are to study airborne and ground-based observations of planetary spectra, to obtain in the laboratory the spectroscopic parameters needed to analyze the observatory spectra, and to develop the analytical and computational techniques to interpret the spectra in terms of real planetary atmospheres. Spectroscopic parameters, such as absorption line and band intensities and absorption line half-widths, as well as their dependence on pressure and temperature, will be obtained for molecules of planetary interest using long path gas cells, cooled and heated gas cells, and high resolution spectrometers and interferometers operating primarily in the infrared. Aircraft spectra of the planets and their satellites will be obtained and analyzed to obtain information about the composition and structure of their atmospheres and the composition of their surfaces.

W76-70648 **196-41-71**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

GROUND-BASED OPTICAL ASTRONOMY

D. P. Burcham 213-354-3028

The general objective of the Ground-based Optical Astronomy task is a comprehensive study of solar system bodies by means of ground-based astrophysical observations in visible and near-infrared wavelengths (approx. 0.3 to 2 microns). Several sub-tasks are included in this task. They are as follows: (1) planetary spectroscopy, to investigate the physical and chemical properties of the upper tropospheres of the planets Uranus, Venus, Jupiter, and Saturn, through high-resolution astronomical spectroscopy; (2) Io sodium d-line patrol, to investigate the spatial and temporal behavior of the Na D-Line emission from the Jovian satellite Io (J-I) through a coordinated program of photometric imaging and high-resolution spectroscopy; (3) asteroid photometry, to determine physical properties (color, albedo, rotation period) of a selected sample of minor planets through a program of multi-color photometry; (4) planetary and satellite photometry, to determine the composition and physical properties of the surfaces of solid bodies in the solar system, particularly outer planets' satellites and to provide photometric information for interpretation of atmospheric composition and structure of the outer planets, particularly Uranus, through use of Multifilter photometry from 0.3 to 2.5 microns and SIPS imaging; (5) comet studies, to obtain basic chemical and physical information on a large sample of known comets, through a coordinated program of photometric imaging (SIPS) and spectroscopy; (6) natural satellite patrol, to provide raw positional data on the satellite systems of Jupiter and Saturn; (7) infrared multiplexing camera, to obtain improved infrared (1 micron to 2 micron) images of Jupiter in order to investigate spatial and time-variable phenomena observed in the Jovian cloud deck; (8) to investigate reported asymmetry in the brightness of the ansae of Saturn's rings in the near IR.

W76-70649 **196-41-72**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

GROUND-BASED INFRARED ASTRONOMY

D. P. Burcham 213-354-3028

(196-41-74)

The purpose of this effort is to obtain and analyze high-resolution near-infrared (1-6 microns) spectra of the planets in direct support of ongoing and planned planetary missions. The principal equipment employed is the Mk 3 Connes'-type Fourier spectrometer at the 2.7 m telescope, McDonald Observatory, but ancillary approaches such as laboratory infrared spectroscopy, theoretical radiative transfer, model atmospheres and spectrum synthesis are also employed. We also undertake the development of new instrumentation to enhance capabilities for this work. To this end, a design study for a new phase-modulated Fourier spectrometer for the NASA 3 m telescope at Mauna Kea is to be undertaken.

W76-70650 **196-41-73**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

RADIO AND RADAR PLANETARY STUDIES

D. P. Burcham 213-354-3028

The ongoing objective of the radio astronomy task is to conduct comprehensive studies of the atmospheres, magnetospheres, and surfaces of planets and their satellites. Theoretical models are constructed and radio astronomical observations are made to test the models and provide input for theoretical refinements. Primary interest is currently focused on Venus, Mercury, and the four major planets and their satellites. The observational experiments are conducted at JPL's Table Mountain Observatory (TMO), the Deep Space Network Tracking Stations, Caltech's Owens Valley Radio Observatory (OVRO) and other observatories as required by specific needs of the program. Research programs at these facilities are planned in order to take full advantage of the unique capabilities of the individual systems, especially the new 36 GHz interferometer at TMO and the 64-m antenna and advanced low-noise receivers at the DSN stations. The objective of the DSIF radar astronomy task is to obtain radar data on the planets for determining properties of their surfaces, orbits and spins, with Venus, Mercury, Mars, Saturn's rings and Jovian Satellites as prime goals. This work employs the unique facilities of the DSIF, and exploitation of synthetic aperture techniques. The microwave radiometer development effort is supportive of the radio astronomy task. The objectives are to design, construct, and maintain advanced microwave radiometer systems and associated digital systems for use at the Table Mountain, Goldstone, Owens Valley and other radiotelescope facilities that are used by the group. Immediate specific objectives are to maintain and upgrade the existing equipment and to expand the operation of the 36 GHz interferometer to the two-baseline capability.

W76-70651 **196-41-74**

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

INFRARED SPECTROSCOPY

D. P. Burcham 213-354-3028

(196-41-72)

The objective of this activity is to determine those parameters

of molecular absorption spectra which will be of use to astronomical and space flight studies of planetary atmospheres. There are two main functions, namely: (1) to furnish quantitative band or line data chiefly at infrared wavelengths, and (2) to provide direct aid in verifying identifications of features observed in planetary spectra. The primary facility employed in this task is the Spectroscopy Laboratory which contains spectrometers covering the visible, near and middle infrared spectral regions and absorption tubes capable of providing path lengths up to 200 meters.

OFFICE OF TRACKING AND DATA ACQUISITION

Supporting Research and Technology

W76-70652 **310-10-22**
Goddard Space Flight Center, Greenbelt, Md.
MISSION SUPPORT COMPUTING SYSTEMS AND TECHNIQUES
D. S. Woolston 301-982-5571
(310-10-26)

The major objective of this RTOP is to ensure the availability of mission support computing systems to meet the operational needs of forthcoming spacecraft missions. The emphases of the RTOP are in the areas of: (1) orbit determination and orbit propagation; (2) generalized mission support for the shuttle era; (3) flight maneuver analysis techniques; and (4) tracking data processing and analysis. In each of these areas the limitations of existing technology are being explored and more economical and efficient approaches are being sought. Research efforts are directed, for example, at providing rapid, precision orbit predictions valid over long time spans; at improving accuracy and efficiency of computer utilization in image processing by making use of landmark data in orbit determination; at defining mission support requirements in a multi-mission environment; at adapting analytical techniques for orbit prediction to mini-computers; at optimum spacecraft maneuver and control; and at optimum tracking data utilization.

W76-70653 **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
ATTITUDE-ORBIT ANALYSIS
Eugene J. Lefferts 301-982-5508

The objectives of this RTOP are to increase the efficiency and decrease the resources needed to meet the requirements for forthcoming spacecraft missions by (1) the use of new data types from on-board sensors and telemetry to decrease the quantity and usage of tracking data for orbit determination and guidance control (2) the provision of generalized and flexible computing systems using on-board sensors and processors along with small ground computers to increase the speed of information flow and reduce the demand upon the central computer facility and (3) providing standardized sensor combinations, telemetry interfaces and computational algorithms suitable for small computer implementation to effect a reduction in the attitude and orbit determination software development cost. The approach involves the development of computational software to permit the analysis of the coupled attitude-orbit determination process and the generation of suitable efficient algorithms for use on mini-computers. Error analyses and simulations will be developed to examine the sensitivity of sensor combinations and algorithms for the combined models. Analyses of the attitude and orbit determination processes will be performed using on-board sensors and computer systems and small ground-based systems (PDP-11). A research mini-computer facility will be acquired to test and evaluate the algorithms and procedures developed under this RTOP.

W76-70654 **310-10-42**
Goddard Space Flight Center, Greenbelt, Md.
FREQUENCY STANDARD SOURCES
V. S. Reinhardt 301-982-5946
(644-03-15)

This RTOP is to develop improved atomic hydrogen frequency and time standards with a frequency stability of 2 x 10 to the minus 15th power at 10,000s, and with a frequency accuracy of 1 x 10 to the minus 14th power, as well as to aid in the transfer of existing hydrogen maser technology to provide a contractor source of operational hydrogen masers for meeting critical NASA applications such as optical and microwave range and range rate tracking, very long baseline interferometry, and the Spacelab Applications Facility.

W76-70655 **310-10-43**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED LASER RANGING SYSTEMS DEVELOPMENT
T. S. Johnson 301-982-5538
(161-02-01; 502-20-33)

The objective is the field testing and evaluation of advanced prototype ranging systems prior to their acceptance and deployment into the operational laser ranging network. This RTOP will use the components developed under OAST RTOP 506-20-33 and the subsystems developed and tested under OA RTOP 161-05-02, and will integrate these technologies into complete laser ranging ground stations. These advanced ranging systems will be evaluated using the existing tracking facilities at the Goddard Optical Research Facility (GORF). Presently orbiting satellites of the Beacon Explorer and GEOS series, as well as planned geodetic satellites such as LAGEOS will be tracked and range residuals will be evaluated using contemporary geopotential models. Groundbased targets will be employed to establish stability and absolute accuracy levels. Program goals include the demonstration of 5 cm range accuracy in 1975 and the achievement of 2 cm accuracy by 1978. Ground-based and balloon-borne meteorological instrumentation will be employed as required to establish the range increment induced by the nonuniform atmospheric refractivity. In FY-76, extensive field tests of the high pulse rate (30pps) mode locked and frequency doubled Nd:YAG system will be conducted. Such systems operate at relatively low peak powers and therefore offer potential reliability and cost advantages when deployed in the operational laser ranging network. This system approach has been field tested previously only in connection with the lunar retroreflector arrays at reduced pulse rates. The FY-76 field tests at GORF will evaluate system performances with the geodetic satellites for the first time. Intercomparison of these results with those obtained by the more conventional giant pulse ranging technique previously developed at GSFC will provide important direction to the advanced technolog, work required to obtain 2 cm by 1978. System approaches which show a capability for both near-earth satellites and lunar ranging will be emphasized.

W76-70656 **310-10-60**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NAVIGATION ACCURACY ANALYSIS
D. W. Trask 213-354-4878
(310-10-62; 310-10-61; 310-10-64; 310-10-66)

Those DSN tracking system uncertainties which limit spacecraft navigation capability now and in the future will be determined. The effects of the transmission media and uncertainties in platform parameters (SSS location, UTI, and polar motion) represent primary limitations for future missions, especially those to the outer planets. Methods of removing these limitations either by direct calibration or by utilization of less sensitive data types will be developed and analyzed. Calibration techniques include the use of the S/X band dual frequency system for the charged particle component of the transmission media and the water vapor radiometer for the wet component of the troposphere, while a VLBI system is being developed to reduce the uncertainties for the platform parameters. In addition, data types being developed which are less senstive to the above limitations include the use of two DSS to obtain differential VLBI data which measure the spacecraft position with respect to an angularly nearby extragalactic radio source and the use of a single DDS to track one spacecraft with respect to a second angularly nearby spacecraft. In addition to reducing limitations in navigation capability due to the tracking system, this RTOP develops tracking techniques to overcome other limitations such as those arising

from the trajectory design or spacecraft characteristics. Examples include multi-station tracking techniques where the differencing of simultaneously acquired range from widely separated DSS is used to overcome the degradation of single station navigation capability for low declination spacecraft, and the differencing of simultaneously acquired Doppler is used to overcome the problems arising from unmodeled forces acting on the spacecraft.

W76-70657 **310-10-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RADIO METRIC INSTRUMENTATION DEVELOPMENT
R. L. Sydnor 213-354-2763
(310-10-60; 310-10-66; 310-10-69)

The objective of this RTOP is to develop and demonstrate high quality instrumentation and techniques for radio metric data acquisition to support the outer planet satellite, orbiter and entry navigation of the next decade in response to system requirements determined in RTOP 60. These requirements include: a VLBI instrumentation system using tropospheric and charged particle calibration, comparison of bandwidth synthesis techniques, analysis and improvement of ranging systems for long round-trip light time (greater than 1 hr), improvement in DSS time delay stability to 0.2 meters, improvement in frequency and timing subsystem, and study of a high accuracy 10 cm ranging system at X-band to be demonstrated in RTOP 69. Instruments being developed include, (1) improved frequency standards (H masers) for maintaining low Doppler residuals over the long round-trip light times and for maintaining phase coherence over the integration time required for Very Long Baseline Interferometry (VLBI) based data types, (2) equipment and circuits to stabilize and calibrate the time delay of the DSS to produce more accurate range and Doppler data, and (3) inter-site frequency and time synchronization system for support of accurate multi-station data types. The techniques developed under this RTOP include, (1) optimal time synchronization methods, (2) system engineering of the DSS for use of VLBI-based data and its optimal use, and (3) systems engineering of the Frequency and Timing Subsystem (FTS) to optimize its use for the new data types.

W76-70658 **310-20-20**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING AND DATA RELAY SATELLITE TECHNOLOGY DEVELOPMENT
George Q. Clark 301-982-4034
(310-20-46)

The two objectives are: (1) to provide for the telecommunications simulation of the TDRSS to be used to verify systems performance capability, and (2) to provide for the orderly development of technology to maximize the TDRSS performance capability. Various studies, simulations, and model fabrications will be performed to establish and verify the performance parameters for a TDRSS. Studies will be performed and technology will be developed as required to improve the performance of the TDRSS.

W76-70659 **310-20-27**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK TIMING AND SYNCHRONIZATION TECHNOLOGY
A. R. Chi 301-982-2502

The objectives of this research are: to study and develop techniques for time synchronization, to coordinate time determination methods and dissemination formats to meet NASA needs and network requirements, and to conduct theoretical investigations and experimental tests for network applications. The approach has been the development of a worldwide time synchronization system such as the use of two additional signals in the Navy's OMEGA navigation system. Coordination with the Navy in the transmission of the two additional signals whose frequencies are separated by 250 hertz has been made. These signals are presently being transmitted by two OMEGA stations at North Dakota and Hawaii. A receiver specifically designed for extracting time from OMEGA has been developed and tested. Modifications of the receivers to improve reception for longer range beyond 8000 kilometers are being made. The system precision is plus and minus 2 microseconds on a worldwide basis. An alternate and more advanced approach has been reviewed and planned. Immediate effort will be directed to investigation of the interfacing problems of using a synchronous satellite system to transpond a time synchronized pseudo-random noise (PRN) coded signal from a ground station to the network stations. The technique as well as the hardware coding design has been developed in another program. The precision of this system meets the projected network requirements of 1980, i.e. below one microsecond.

W76-70660 **310-20-31**
Goddard Space Flight Center, Greenbelt, Md.
A GROUND ANTENNA FOR WIDEBAND DATA TRANSMISSION SYSTEMS
A. F. Durham 301-982-4973

Future advanced spacecraft system will transmit data to the ground at rates much higher than that of current operational systems. The Land-sat used for Earth Observation will transmit high resolution color imaging data either directly to a ground station or via a Tracking and Data Relay Satellite (TDRS). The TDRS will transmit signals from Land-sat and other satellites which required total TDRS bandwidths well above 100 MHz. Existing NASA ground stations are not equipped for such data rates. Future wideband communication by TDRS, Land sat and other projects, require use of frequencies at which the necessary bandwidth can be allocated. A wideband system requires a high performance ground antenna system. Emphasis on overall system efficiency will be essential to an economically feasible ground station. In particular, techniques and components will be developed which yield high efficiency antenna systems, feed systems and low noise preamplifiers. In addition, dichroic subreflector techniques permitting simultaneous and efficient operation of an antenna at different frequencies without degradation of overall performance or flexibility will be refined. Analytical procedures and design tools will be further developed to support the specific requirements of these advanced antenna systems and the general antenna development program.

W76-70661 **310-20-32**
Goddard Space Flight Center, Greenbelt, Md.
HIGH RELIABILITY CONTROL SYSTEMS FOR ANTENNAS
N. A. Raumann 301-982-6579

The objective is the development of a high performance servo and control system for large tracking antennas. There is a trend in the networks toward higher RF frequencies, switching from S-band to Ku-band of operation. This switch will require an improvement in tracking accuracy of the antennas from a present 0.9 mrad to 0.2 mrad. At the same time there is a requirement for increased link reliability due to concentration of data acquisition responsibilities and increasing data bandwidths resulting from reduction in the number of network stations. Thus link downtime has to be minimized by providing a high reliability control system and by reducing routine alignment and maintenance requirements. These objectives are met by use of a small digital computer in the antenna tracking loop. An experimental system, the Computer Controlled Antenna System, has been developed under this RTOP and is in operation of the Network Test and Training Facility (NTTF). The capabilities of this system will be extended by development of control algorithms to improve the tracking accuracy and by providing high reliability control system to minimize antenna downtime.

W76-70662 **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
RF TECHNOLOGY FOR TDRSS USER SPACECRAFT
F.J. Logan 301-982-4901
(506-20-24)

The objective of the work under this RTOP is to achieve technological advances in RF and antenna systems in order to satisfy the future requirements of spacecraft projects that require the near global real-time coverage of the Tracking and Data Relay Satellite System (TDRSS). It: (1) identifies the basic operational requirements of these missions; (2) investigates RF components and types of antennas that are available to attain the required parameters; and (3) develops system designs incorporating the optimum subsystems to permit the spacecraft

projects to obtain proven reliable flight hardware within a reasonable time frame. These advances will be utilized in the development of S-band and Ku-Band spacecraft systems, including the antenna, transponder, transmitter and receiver. These systems will be capable of direct communications to ground stations or to the TDRSS.

W76-70663 **310-20-65**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ANTENNA SYSTEMS DEVELOPMENT
H. P. Phillips 213-354-4743
(310-10-61; 310-20-66; 310-30-68; 310-30-69)

This RTOP develops the technology for increasing the communications capabilities of the DSN ground based antennas as a part of optimizing the overall flight/ground communications link for planned NASA missions to outer planets. Communications capability is measured by the antenna figure of merit (ratio of gain to receive system noise temperature); usable operational frequencies (S, X or K bands); and environmental limits of operation. The cost of construction, operation and maintenance are additional factors in ground station performance. The technology developed provides options for spacecraft planning in terms of single or dual frequencies of operation, simultaneous receive/transmit or receive only modes and other configurations with advantages for particular missions. Flight/ground tradeoffs will balance the needs of mission scientific data transmission requirements, spacecraft parameters and DSN capabilities for single or concurrent missions. Overall performance and economy in spacecraft communications, based on these tradeoff studies, are the key objectives of this program. Advances in ground antenna performance are sought in the areas of microwave techniques; antenna structural, mechanical and pointing systems; and in materials and techniques for producing less costly, more reliable antenna components to reduce operations and maintenance costs. Advanced analytical techniques are developed and applied to the improvement of existing antennas and to the design of new, lower cost antennas with appropriate communication capabilities. A study, integrating current developments in all of the interrelated disciplines projects a 3 db improvement in the figure of merit of existing 64-m antennas.

W76-70664 **310-20-66**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RADIO SYSTEMS DEVELOPMENT
Macgregor S. Reid 213-354-3332
(310-20-67; 310-20-65; 310-10-61)

The objective is to improve the spacecraft-to-ground radio system elements of the communications link in order to meet the future navigation and high data rate telecommunications requirements of the planetary exploration program. Future missions to the outer planets will require sensitive receivers and wideband radio communications for high rate video, telemetry, navigation, and radio science data. They will also require calibration and models of the propagation medium and of the DSN ground radio parameters. In order to commit the DSN to a specified X-band performance level, a detailed investigation of the propagation medium is required and is underway. Local weather effects at the DSN tracking station complexes on X-band propagation are being investigated and will ultimately provide DSN specifications for the statistical performance of X-band links for use by flight projects. Equipment will be developed for the radio metric calibration of water vapor in the earth's troposphere in the line-of-sight of the 64-m antennas. The information from the water vapor radiometer will be used to increase the accuracy of radio metric navigation by calibrating the tropospheric delay and to improve the X-band weather model. Other hardware development includes increased bandwidth and reduced noise temperatures of advanced maser/closed cycle refrigerator systems for the DSN. Maser bandwidths will be increased from about 30 MHz to a target of 300 MHz. Reduction of the X-band maser noise temperature from the present value of 7K to 2.5K will improve the received signal-to-noise ratio by 0.7 db. Other radio frequency measurement development work supports the precision monitoring and calibration of the ground receiving system, antenna gain, system temperature, pointing accuracy, spacecraft received power level and range delay.

W76-70665 **310-20-67**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
DIGITAL SYSTEMS DEVELOPMENT
R. A. Winkelstein 213-354-3843
(310-20-66; 310-30-68; 310-30-69; 310-40-72)

The objective of this RTOP is to develop digital data handling systems which permit effective communications between earth and spacecraft for mission types of the next decade while minimizing the cost of such communications. The entire communication link from the Mission Control and Computing Center to the spacecraft and back again will be considered in order to tradeoff spacecraft/ground system configurations which will result in highest efficiency and low overall costs to NASA. In particular, a multiple rate flight/ground command system will be developed and demonstrated in FY-76. This system will permit more rapid entry of commands during periods when the uplink to the spacecraft can support higher data rates thus optimizing operations when more than one spacecraft must be sequentially commanded from a single DSN station. In support of tradeoff studies, computer decoding simulations will be developed to verify predicted threshold performance under adverse conditions such as the effect on sequential decoding thresholds when Pioneer Venus 78 transmits through the fading and turbulent transmission path of the Venus atmosphere. Studies will also be made of telemetry bit rates in the 5 megabit per second range required for high data rate missions such as the Mariner Jupiter Orbiter and the Venus Orbital Imaging Radar missions. In addition, two specific designs are being studied and developed: (1) a concatenated algebraic convolutional code which will be used on the Viking 75 X-band telemetry demonstration similar to the demonstration on Mariner 10, and (2) a digital phase locked loop receiving system for optimum reception of signals transmitted through a dispersive medium and for rapid receiver reconfiguration when communicating with more than one spacecraft from a single DSN station during a common view period.

W76-70666 **310-30-24**
Goddard Space Flight Center, Greenbelt, Md.
WIDE BAND STATION DATA HANDLING EQUIPMENT
Henry J. Franks 301-982-2649

Future NASA Programs such as the Earth Observatory Program require a data handling capability as high as 240 Megabits per second (Mbps). The Goddard Spaceflight Tracking and Data Network (STDN) presently has a maximum data handling capability of 15 Mbps. The STDN presently operates at VHF and S-band which cannot accommodate the bandwidth required for the above mentioned program. The objective of this RTOP is to develop prototype equipments that can accommodate these high data rates.

W76-70667 **310-30-68**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STATION MONITOR & CONTROL SYSTEM TECHNOLOGY DEVELOPMENT
R. Bruce Crow 213-354-3291
(310-30-69; 310-30-70; 310-30-72)

The general objectives of an approach to this work are to: (1) assess the present DSS subsystem technology in its applicability to automated station design considering long term equipment stability, complexity, maintainability, and reliability; (2) specify, in conjunction with RTOP 69, 70, and 72 future DSS system and subsystem technology for high performance automation application including digital signal processing, hierarchial control philosophy, interface philosophy, and minicomputer/micro processor architecture and software. (A) Conduct specific development of representative automatic subsystem assemblies which fit automation objectives. Obtain support from RTOP 72 for Control and computation Modules applications; (B) conduct demonstration of RF/microwave/antenna subsystems, automatic calibration, acquisition, failure back-up/diagnostics, rapid reconfiguration and real time monitoring and logging. The software design is to use structural, top down design using high level language; (C) guide the station system level automatic design. Support feasibility studies using management science techniques for life cycle cost determinations and collect an automation data base for cost-benefit analyses in RTOP 70.

W76-70668 **310-30-69**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TRACKING STATION SYSTEMS TECHNOLOGY
R. R. Green 213-354-3015
(310-40-68; 310-40-70; 310-40-72; 310-40-65)

The objectives of this RTOP are to develop, and demonstrate new station systems capability and new network technology required to support deep space missions in the next decade. The 400 K watt (8.495 GHz) X-band transmitter development demonstrated in RTOP 64 in FY-75 will be refined and exercised further via planetary radar experiments. Additional work in this area will include development of components to operate at the 7.1 to 7.25 GHz X-band frequency assigned to the DSN. Waveguide components needed to handle high power at low loss will also be developed and tested. Development of wideband-width high-density magnetic tape recorder system for VLBI, predetection and postdetection of high rate telemetry started in FY-75 will be continued. Also, the development and testing of an automated, computer controlled antenna pointing system, a station controller, and interfaces will proceed toward an ultimate automated station demonstration in conjunction with RTOPs 68, 70 and 72. Finally, the planetary radar system which serves as test-bed will be expanded to utilize and test the increased capability offered by X-band. Side benefits obtained from the planetary radar experiments include data on the transmission medium at X-band, updated ephemerides to the planets, and planetary surface characteristics, useful for flight project planning.

W76-70669 **310-40-25**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC SYSTEM FOR COMPUTER PROGRAM DOCUMENTATION
E. P. Damon 301-982-6886

The objectives of this RTOP are to extend the capabilities of the Automated System for Computer Program Documentation in order to (1) operate on the Univac and CDC computers, and (2) to provide the necessary tools which will help measure, manage, predict, and categorize errors which occur in software in order to control software reliability. The plan of activity will include: (1) define categories of errors; (2) measure parameters for the software reliability study; (3) develop reliability model (prototype); (4) evaluate existing software reliability techniques and determine proper areas for advance study; (5) study and develop techniques to improve reliability; (6) structured programming; (7) program management techniques (a) chief programmer team, (b) computer program management technique; (8) proving programs correct; and (9) conclusions and recommendations.

W76-70670 **310-40-36**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC DATA HANDLING
J. C. Rodgers 301-982-4189

Improvements to meet the large increases in support requirements demanded by NASA's future space programs specifically include a higher level of automation for Goddard Space Flight Center (GSFC) facilities resulting in increased data and information exchanges between the various GSFC facilities. This RTOP shall study methods of handling data and information and shall result in two end products: (1) the design and development of a prototype Integrated Telecommunications Distributions System providing a communications network between the Operational M&DOD computers, and (2) the design and development of the Data Accountability System with the necessary capability to monitor, coordinate, and account for the data messages transferred between the remote ground stations and the GSFC facilities. The Integrated Telecommunications Distribution System will interconnect existing M&DOD computer systems and will permit any computer on the telecommunications network to communicate with any other computer on the network. The Data Accountability System shall interface with the M&DOD computer facilities and NASCOM concentrating on the particular problems inherent in data coordination, and accountability when data is automatically transmitted between ground stations and GSFC by computer-to-computer transfers.

W76-70671 **310-40-38**
Goddard Space Flight Center, Greenbelt, Md.
COMPUTATIONAL REQUIREMENT - DEFINITION
A. Goodson 301-982-5308

The functional capability of the M&DOD computer facilities is continually being reassessed in the light of present and future mission support requirements, advances in computer technology, and cost-effectiveness considerations. The purpose of this RTOP is to find practical answers to different aspects of this problem. Emphasis is on using advanced tools and techniques to define computational requirements and to determine alternative means of meeting these requirements. To meet this objective the following action will be taken: (1) identify functional requirements of users; (2) identify current system and user demands, and (3) develop functional configurations.

W76-70672 **310-40-39**
Goddard Space Flight Center, Greenbelt, Md.
IMAGE PROCESSING FACILITY PERFORMANCE EVALUATION AND IMPROVEMENT
J. Y. Sos 301-982-2841

In the future several new Office of Applications (OA) projects, such as AEM, NIMBUS-G, SEASAT, will require image data processing capabilities. It is planned to augment the existing GSFC>image processing facility (IPF) to support, in addition to LANDSAT, the above projects. This plan proposes to conduct studies leading to the development of specifications for new IPF equipment, to define operational concepts for the facility, and to continue the development of efficient image processing algorithms. To assure achievement of high performance it is necessary to develop efficient performance monitoring techniques, parameters to characterize product quality, and obtain instruments to implement the techniques in conjunction with existing and planned IPF hardware. It is also necessary to study methods for generating image products that could be less expensive and more useful to the investigator, and to eliminate un-needed and expensive products. This plan proposes to develop efficient and accurate methods and equipment for monitoring and controlling performance of image processing systems, and assuring the quality and usefulness of products generated in the IPF. Higher time resolution will be required on future spacecraft consistent with more sophisticated experiments and with the desire to correlate data from one spacecraft with data from another. It is necessary to study several spacecraft systems with different types of timing problems.

W76-70673 **310-40-40**
Goddard Space Flight Center, Greenbelt, Md.
PROJECT OPERATIONS CONTROL CENTER COMPUTATIONAL SYSTEM OF THE 1980's: POCCNET
R. DesJardins 301-982-6223

The goal of this RTOP is to develop a control center computational system design (hardware/software) for the 1980's, christened POCCNET, embodying the following features: (1) ultrareliable, fail-soft hardware/software design, (2) high visibility of sytems implementation status and operational state, (3) virtualization of computational system functions, (4) flexibility and ease of reconfiguration, simplified integration and test, (6) reduced development time and cost, (7) special attention to human interfaces and to software engineering, (8) low-cost standard software and supporting services for the low-cost modular spacecraft (LCMS). The effort will be subdivided into four elements: (1) identify probable computational requirements on GSFC Project Operations Control Centers anticipated in the 1980's due to Shuttle, TDRSS and LCMS; (2) identify applicable advanced technologies, and develop specifications for minicomputers, high-speed serial channel and telemetry input preprocessore; (3) identify applicable software engineering methodologies, specifically including comparisons of systems implementation languages and software design methodologies, and (4) design POCCNET subsystems in both the systems and applications areas.

W76-70674 **310-40-41**
Goddard Inst. for Space Studies, New York.
COMPUTER USAGE TECHNIQUES
Paul B. Schneck 212-678-5617

The objective is to develop and apply techniques for: (1) increasing the efficiency of current computer systems; and (2) identify criteria for the selection of future GSFC computer systems. The three areas leading to this objective are: (1) Operating Systems: Designs and approaches to improve system performance, identification of hardware requirements necessary for effective performance; (2) Program Performance: Construction of automatic program improvement (optimization) facilities to decrease the running time of programs; (3) Parallel/Vector Processing: Construction of automatic facilities for converting existing (serial) programs to forms suitable for use on machines with parallel and vector architectures. The approach will be: (1) Operating Systems. A mathematical model of a computer system will be extended to show hardware/software tradeoffs, and the best investment strategy (in terms of configuration selection) for a given dollar cost. Input to the model will come from a hardware monitor which will be attached to the GISS computing facility; (2) Program Performance: The FORTRAN and FORTRAN Optimizing Compiler will be extended to include additional machine independent program optimizations. The compiler will be brought to a fully operational status and placed in regular use at GISS and GSFC. A preliminary version of the compiler is in use at CERN, The World Bank, SLAC, IBM, Sandia, IRIA and has been distributed to many other laboratories, both domestically and internationally. At the current time it often reduces program running time by 10-20 percent. (3) Parallel/Vector Processing: The Parallel Vector Compiler (common with the FORTRAN to FORTRAN compiler) will be extended to perform translation to a real language for parallel computation, e.g., CFD for the ILLIAC computer. This compiler will also be made operational so that it may be used for evaluating the applicability of new parallel and vector machines to current GSFC programs.

W76-70675 **310-40-70**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NETWORK MONITOR, CONTROL AND OPERATIONS TECHNOLOGY
Richard R. Green 213-354-3015
(310-40-68; 310-40-69; 310-40-72)

This RTOP considers the Deep Space Network (DSN) as a single large distributed system. Within this system there are no important types of information flow. Operational control information originates from a single centralized source and must be distributed to each of the several Deep Space Stations (DSS). Tracking, telemetry, and station status information may originate at any of the stations and must flow back to the centralized collection point. The tolerable error rate for the outgoing operational control information (station configuration, spacecraft commands, etc.) is extremely low, less than 1 part in 10 million. The incoming station originated data can tolerate somewhat higher error rates, typically 1 part in 100,000. This RTOP is (1) developing communication techniques to achieve the required low errors rates, (2) evaluating control techniques for minimizing required communication bandwidth and for achieving immunity from single points of failure, and (3) investigating techniques for developing network monitor information into a useful aid for effective DSN management, long range planning, and providing cost-benefit analyses. Several achievements are planned in FY-76 to realize these objectives. A demonstration of communication error control techniques will be conducted using the high speed data lines to communicate with DSS-14. The remote automatic control pulsar data collection system will be operated to obtain data on remote control techniques. Using that data as a base, the first part of an advanced automation demonstration system at DSS-14 will be constructed. Information obtained from the pulsar automation demonstration, the RTOP 68 RF automation demonstration, and from DSN maintenance activities will be integrated into a data base for evaluating alternative management and control methods, and system designs for the DSN.

W76-70676 **310-40-72**
Pasadena Office, Calif.
NETWORK CONTROL AND DATA PROCESSING DEVELOPMENT
J. W. Layland 213-354-2757
(310-40-70; 310-30-68; 310-30-69)

The objective of this RTOP is to develop the techniques necessary for the efficient and cost-effective application of computational resources to the jobs of the DSN. New methods allow the design of systems utilizing hardware and software to be performed in a top-down hierarchial fashion to satisfy functional requirements thereby enabling effective management control of system development. The economical partitioning of the elements of a functionally designed system between hardware/firmware/software in a way which satisfies real-time system constraints is a tractable resource-allocation problem within the framework of a hierarchical design. Rules for structured programming and hierarchical design of software systems are being developed via the machine-independent design of a language processor for MBASIC. The MBASIC language itself encourages structured hierarchical software development, and is a proposed standard for all management-oriented computer data access. Maintenance of logical hardware in the network environment represents another sizeable cost item for the DSN. This cost is being attacked through the development of a standard set of logical building blocks, the Control and Computational Modules, which will be used for the fabrication of a variety of digital systems, from a dedicated signal processor to a multipurpose digital controller. The automation development experiments led by RTOP 310-40-70, and RTOPS 310-30-69 and -68 are supported in part by computer technology developments in the RTOP. This involvment includes but is not limited to participation in the development of computer communications protocol, interfaces, and software; and the evaluation of impacts of changing minicomputer/microcomputer technology on future network implementation of automated subsystems.

OFFICE OF MANNED SPACE FLIGHT

Advanced Development

W76-70677 **910-01-00**
Marshall Space Flight Center, Huntsville, Ala.
STRUCTURES
C. Loy 205-453-3960

The objective of this RTOP is to establish design, analysis, fabrication, and inspection techniques to provide lightweight, reliable pressurized and unpressurized structural systems for reusable space vehicles and payloads used on the space shuttle. Use of composite materials will be emphasized where applicable. Development of reliable meteoroid shielding data is planned. To accomplish these objectives, the following tasks will be performed: (1) Task 31, lightweight shell structure; (2) Task 54, thin gage propellant tank design, fabrication, and test; (3) Task 61, bending/stretching coupling of laminated composite plates; and (4) Task 62, structural analysis of solids. Through fabrication and testing of large structures, close to full scale, representative of a propellant tank and unpressurized external shell, the viability of selected materials, design, analysis, and fabrication techniques will be demonstrated. Selected structures will have all required attachments, and weights derived from test hardware will give realistic data for reusable space vehicles and payloads.

W76-70678 **910-02-00**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL
J. L. Vaniman 205-453-1171

Space transportation systems thermal control is the maintenance of thermally sensitive equipment and structures within specified critical temperature limits through the control of heat flow to and from such equipment. Equipment includes (but not limited to) such items as electronic components, optical sensors, fuel cells, batteries, APS systems, and hydraulic systems. Studies show that sophisticated semi-passive thermal control methods which require state-of-the-art advancements are required to maintain satisfactory thermal conditions under the environmental extremes encountered by future space transportation systems. The objective of this continuing effort is to analyze, design, and

develop thermal control systems (including hardware) and demonstrate system application and feasibility for maintaining thermally critical hardware within specified thermal units. To accomplish these objectives, the following tasks are to be performed: (1) Task 31: thermal control breadboard; (2) Task 32: electronic equipment internal thermal control; (3) Task 51: low temperature thermal control; and (4) Task 54: temperature mixing control device.

W76-70679 **910-02-03**
Lyndon B. Johnson Space Center, Houston, Tex.
THERMAL CONTROL
W. E. Ellis 713-483-4941

The primary means for rejecting heat from current manned spacecraft while on-orbit has been through a space radiator system which is mounted on the skin of the vehicle and which rejects heat from a fluid circulating through it by radiation to the space environment. The primary goal of this activity is to develop a radiator system which is not integral with the spacecraft skin, and can be separately developed and manufactured. The independent development approach has signficant potential to reduce spacecraft development costs by (1) reducing development and qualification testing, (2) providing a longer production run, (3) simplifying integration between the heat rejection system and vehicle, and (4) reusing heat rejection systems which are returned from orbit on other experiments. This activity has applicability to a very broad range of future possible missions, and could result in significant overall cost savings during spacecraft development and operations. Two separate advanced space radiator concepts will be pursued in an integrated effort to develop multi-mission use, low-cost heat rejection systems which can overcome the limitations of current radiator systems. These concepts are not considered to be competitive alternatives, but unique design approaches which have the combined capability to meet a wide range of specific advanced mission requirements at minimum costs. Two supporting tasks will be pursued which have application to either of the separate advanced space radiator concepts being developed: advanced heat rejection control techniques, and lightweight radiation fin development.

W76-70680 **910-03-00**
Marshall Space Flight Center, Huntsville, Ala.
MAIN PROPULSION
H. Pratt 205-453-3623

Activities described in this RTOP will utilize data from a current contracted effort to design, fabricate and verify through cold flow component test a lightweight, compact, oxygen/hydrogen heat exchanger suitable for use in an engine system for tank head idle mode operation. In a separate task design, fabrication and mechanical test activities will be pursued to validate the mechanical integrity and alignment characteristics of a translating nozzle actuation mechanism and a primary nozzle-nozzle extension seal. Out-of-house contracted efforts will be pursued. All testing will be performed at contractor facilities. The RL10 engine system will be used as the base for component sizing. Sufficient hardware will be fabricated to allow incorporation into an existing government furnished engine system at a later date.

W76-70681 **910-03-00**
Lewis Research Center, Cleveland, Ohio.
ADVANCED H2-O2 ENGINE COMPONENT TECHNOLOGY
John W. Gregory 216-433-4000
(506-21-11)

The objective of this program is to provide improvements in the technology of the components applicable to advanced, high performance reusable hydrogen-oxygen rocket engines. Such engines must operate reliably in space for long periods of time and provide many restarts during a minimum of 20 missions. Included in this program are efforts on components such as: thrust chambers, bearings and seals for turbopumps, and complete turbopump assemblies. Technology will be developed for long life, small, high speed bearings for liquid hydrogen turbopumps. Both rolling element and hybrid (fluid film) bearings of 20 mm size (shaft diameter) will be evaluated. Bearing design and fabrication were provided under contract, and bearing testing will be performed in-house at LeRC. LH2 Pump testing will be performed with hybrid bearings installed. Effort will also be applied to the design, fabrication, and testing of controlled fluid film seals for small, high speed liquid oxygen turbopumps. This contract effort will evaluate seals of 30 mm diameter capable of 10 hours operational life and 300 start/stop cycles at shaft speeds up to 90,000 rpm. Work was initiated in FY-74 on the design, fabrication and acceptance test of a high pressure (up to 4400 psia) liquid oxygen turbopump. Complete performance testing of the pump will be done in FY-76.

W76-70682 **910-03-00**
Lyndon B. Johnson Space Center, Houston, Tex.
PROPULSION
C. W. Yodzis 713-483-4924

The objectives of this RTOP are to improve the propulsion systems for post-shuttle programs. Improvements will be achieved by taking advantage of promising design concepts in the areas of (1) high frequency stability, and (2) nonintrusive flowmeters. Current acoustic cavity designs are only effective over a narrow range of frequencies. Recent testing with dual mode configurations indicates that this range can be increased to a more desirable range. Non intrusive flowmeters are desirable since they are not exposed to propellants and should have long life. Methods of increasing their accuracy to 1%, however, are required and have to be further developed.

W76-70683 **910-04-00**
Marshall Space Flight Center, Huntsville, Ala.
ATTITUDE CONTROL PROPULSION
F. F. Garcia 205-453-1242

This effort will demonstrate a service life of a minimum of 20 missions and the extent of performance variations of an improved hydrazine thruster throughout its service life. The performance and endurance of a passive propellant management system for zero-g operation will also be deomonstrated. A hydrazine thruster for an attitude control propulsion system (ACPS) employing the radial flow catalyst bed technology developed for the space shuttle orbiter APU gas generator will be designed, fabricated, and tested. A passive propellant management system employing a surface tension device of the type being developed for the space shuttle orbiter RCS will also be designed, fabricated, and tested.

W76-70684 **910-04-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATTITUDE CONTROL PROPULSION
P. J. Meeks 213-354-2546

The objectives of the work contained in this RTOP are: (1) to tie-off, in a logical manner, the resonance ignition work, and to disseminate the information in the most cost-effective method so that it is available to any potential user both within interested governmental agencies and private industry; (2) to initiate a design study, in conjunction with JSC to implement the substitution of hydrazine N2H4 for monomethylhydrazine (MMH) in the reaction control and orbital maneuvering systems on-board the space shuttle; and (3) to initiate a contracted design study to adapt the RCS main engine to N2H4/N2O4 from MMH/N2O4.

W76-70685 **910-05-00**
Lyndon B. Johnson Space Center, Houston, Tex.
SOLID POLYMER ELECTROLYTE FUEL CELL TECHNOLOGY
G. D. Hydrick 713-483-3286

The objective of this program is to provide achievable advancements in the solid polymer fuel cell technology for application to space power generation. It is proposed to take advantage of the inherent characteristics of the solid polymer ion exchange fuel cell; i.e., long life, invariant performance, low specific weight (#kw) and low specific cost ($/kw) in a phased technology program which offers potential benefit and advancement to system design of the next generation of solid polymer electrolyte fuel cells. Approach - The program will be conducted in a phased effort which represents a continuation of contractor in-house effort, the NASA funded Space Shuttle technology program and the United States Air Force Biosatellite H2/O2

fuel cell program. The primary phase of the program will address the electrochemical performance improvements of the basic cell assembly applicable on hydrogen-oxygen and low purity reactants. Subsequent phases will utilize the results of previous phases with evolution of hardware design and test directed toward defined goals relative to use, size, power cost, weight application, ect.

W76-70686 **910-05-00**
Marshall Space Flight Center, Huntsville, Ala.
ELECTRICAL POWER
R. M. Aden 205-453-4950

The effort described in this RTOP is in support of space systems in the electrical power area. The objectives of this program are to develop essential technology, design requirements, and design specifications and to perform component research and breadboard/prototype development necessary to produce flight qualified hardware for long life, cost effective power systems. To accomplish these objectives, the following tasks will be performed: (1) Task 31: Switch Gear and Circuit Protection. Perform necessary research and discrete part evaluation to fabricate breadboard power controllers to switch loads in the 3 to 20 ampere range. (2) Task 32: Power Conditioning. Develop power conditioning circuits and equipment in which built-in test, system monitoring and control, and advanced concepts will be investigated. Standardized load center and central power supplies and inverters will be designed, built, tested, and qualified. (3) Task 61: Feed- Thru Electrical Connectors. Develop a statement of performance, design requirements, and conceptual configurations and fabricate acceptable cryogenic feed-thru connectors.

W76-70687 **910-07-00**
Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS
Jack G. Sheppard 713-483-6301

This RTOP will improve the productivity of communications and tracking systems to support Spacelab, payloads, and subsequent programs. Improvements will be achieved by taking advantage of advances in solid-state electronics, particularly in LSI (large scale integration). Other gains will be achieved by transmission system improvements at new frequencies. Television will be important in future programs. It will gather experiment data, control payloads, assist docking operations, inspect damage and provide information to users on the ground. These diverse uses require a family of cameras, monitors, and controls. It is highly desirable that these components be solid state. This RTOP continues the design of required systems and development of key components. RF spectrum crowding and data rates are driving systems to higher frequencies both microwave and optical. Certain key components required for satisfactory implementation must be developed. These new systems offer greater performance, but require careful implementation. In particular, the integration and operation of electronics and antennas must be investigated to ensure that propogation losses do not negate the advantages of operation at higher frequencies. RF spectrum crowding also is impacting tracking systems such as radars. The use of communication techniques, such as spread-spectrum, hold promise of greater power and performance within the evolving electromagnetic spectrum constraints, and they will be applied to radar systems.

W76-70688 **910-07-01**
Marshall Space Flight Center, Huntsville, Ala.
COMMUNICATIONS
D. O. Lowrey 205-453-1578

The objective of this effort is to develop active electronically steerable microwave phased array systems operating in the S-band and Ku-band frequency regions for space communications and tracking purposes. These systems will provide high data rate, telecommunications capability with simultaneous or separate transmit, receive and tracking functions. Considerable system advancement and performance with decreased size and weight will be realized over conventional systems using separate transmitters, receivers, antennas, transmission lines, control and driving motors, and associated supporting structures. This is a continuing effort that will produce active electronically steered phased arrays that are lightweight, highly redundant, have low d.c. power drain, uses 100 percent microwave integrated circuitry and utilizes a modular building block construction concept with standardized modules for maximum design versatility and minimum cost. The study of application of active electronic modular techniques to the Ku-band electronically steered phased array will be continued. The most critical devices and circuits will be fabricated and laboratory tested in descending order of criticality to verify the design performance.

W76-70689 **910-07-06**
John F. Kennedy Space Center, Cocoa Beach, Fla.
COMMUNICATION
C. H. Bell 305-867-3842

The objective of this effort is to demonstrate the installation, operation; and maintenance of a wideband fiber optic cable transmission system. Field tests will be conducted at KSC in an operational environment in order to determine and define the installation and maintenance requirements for a fiber optic cable system.

W76-70690 **910-08-00**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED DEVELOPMENT: STABILIZATION AND CONTROL
S. M. Seltzer 202-453-4580
(893-78-57)

The approach will be to: (1) develop and exploit modern control theory techniques to assure satisfactory performance of instrument pointing system (IPS), in the presence of such effects as vehicle flexibility, sensor and actuator nonlinearities, and digital implementation (sampling); and (2) study the dynamics and control problems of multiple space deployment from the tug. Define deployment mechanism requirements, deployment technique and the impact of multiple deployment on the Tug attitude control system design, including a definition of candidate mechanisms which satisfy these requirements. Accomplishment of these objectives requires as a minimum the following tasks: Task 61 - Observability and Controllability Analysis: Determine the critical vehicle states of the flexible vehicle. Select and place sensors and actuators to enhance their observability and controllability. TASK 62 - Digital Controller Design: Analyze IPS nonlinearities, such as quantization, actuator friction and sampling, to determine conditions for limit cycles in order that they may be minimized by proper design. Employ previously developed digital redesign technique to design the digital controller.

W76-70691 **910-08-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INSTRUMENT POINTING SYSTEM TECHNOLOGY FOR SPACE LABORATORY
Robert V. Powell 213-354-6586
(506-19-14; 186-68-54)

The Instrument Pointing System (IPS) being developed by ERNO, et al for Spacelab must accommodate a wide variety of Earth pointing and astronomy payload requirements. A high precision pointing system is required for orientation and control of the on-board scientific instruments. The most cost effective approach in the development of the IPS would maximize the utilization of Low Cost Systems Office (LCSO) components and near-term-ready OAST-sponsored control system technologies. The objective of this effort is to develop a plan for the integration of LCSO and advanced development technologies which could accommodate instrument requirements and result in significant cost savings for future IPS hardware. The plan will be based on supporting studies of IPS requirements; technical interactions with NASA Hqrs. and Centers, and ERNO; and system simulations.

W76-70692 **910-09-00**
John F. Kennedy Space Center, Cocoa Beach, Fla.
SAFETY
R. J. Cerrato 305-867-2780

The disposal of hypergolic liquids and vapors at KSC in such a way as to minimize effluent effects on the environment is a project that is continuing, based on criteria developed under contract NAS10-8399, Hypergolic Propellants Liquid and Vapor Disposal. Activities will include the evaluation of microwave

decomposition as a vapor disposal technique, the operation and evaluation of a prototype liquid disposal pond and the preliminary investigation of state-of-the-art concepts suitable for the disposal of fluorine compounds and diborane fuel. The construction and testing of two full-scale prototype vapor scrubbers of advanced design (one for fuel vapor and one for oxidizer vapor) will be accomplished. In support of the large quantities of hydrazine fuels to be utilized at KSC in the future, the development and testing of an engineering prototype hydrazine sensor which is suitable will be initiated.

W76-70693 **910-10-00**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE AND NAVIGATION
B. F. Walls 205-453-5910

This RTOP describes the program of research and technology development planned in the guidance and navigation area to establish an adequate technology base for the design and development of the space tug. The objective of this effort is to provide advances in the state-of-the-art in the inertial measurement unit and the scanning laser radar sufficient to support the design and development of the space tug mission requirements. The approach is the inhouse performance of specific improvements in operational characteristics, weight, cost and reliability of the guidance and navigation systems and components. This program takes advantage of other ongoing development programs at MSFC, such as the SUMC computer funded by OMSF and the laser gyro funded by OAST.

W76-70694 **910-13-00**
Lyndon B. Johnson Space Center, Houston, Tex.
INSTRUMENTATION
W. L. Craddock 713-483-5171

The Space Environment Simulation Laboratory at JSC represents the state of the art in advanced thermal-vacuum test (space simulation) facilities. Continuing efforts are being made to reduce required manpower and total operating costs, while maintaining the high standards of test posture and capability of the facilities. Research is required to understand and predict operational characteristics as they apply to actual thermal-vacuum chambers, payloads, and spacecraft. This is to include low cost techniques for optical refurbishment and fabrication, a more refined analytically predicted thermal model, corona phenomena, test articles geometric shapes and surfaces; and to develop methods and systems for identification, measurement, control and improvements. To accomplish the objectives of this RTOP the following tasks are proposed: (1) Task 32 - Corona Detection System (continuing effort); and (2) Task 41 - Lambertian/Specular Sources, (SCATE) (continuing effort), and (3) Task 53-Data Acquisition and Control System (NIM/CAMAC).

W76-70695 **910-13-00**
Marshall Space Flight Center, Huntsville, Ala.
ADVANCED INSTRUMENTATION (CONTAMINATION)
R. J. Naumann 205-453-0940
(506-16-35; 750-01-71)

Previous work performed under a combination of this RTOP and RTOP 506-16-35 has resulted in the induced environment monitor (IECM) which is a complement of instruments designed to verify all the contamination requirements specified in JSC 07700 during the shuttle OFT Series and early spacelab missions and provide diagnostic data on any out of specification condition so that it can be corrected before operational flights begin. Additional requirements have recently been identified by the contamination requirements definition group (CRDG) which require advanced instrumentation techniques in ultraviolet photometry, infrared radiometry, mass spectroscopy, gamma ray spectrometry and magnetometry. It is proposed that the primary emphasis of the RTOP be directed toward developing the advanced instrumentation to perform the measurements specified by the CRDG on the early shuttle and spacelab flights. To accomplish this objective the following tasks are required; (1) Task 51: Conduct an instrument definition study to determine measurement techniques, instrument requirements, survey of availability of existing instruments, and development of engineering prototypes to measure the size, velocity, and trajectories of particulates; the ultraviolet background; the infrared background; the molecular column density; the gamma ray background; and the magnetic background to the levels specified in the CRDG requirements. (2) Task 52: Continue development of electrets as a contamination control and collection device.

W76-70696 **910-13-00**
John F. Kennedy Space Center, Cocoa Beach, Fla.
INSTRUMENTATION
R. J. Cerrato 305-867-2780

The objectives of this project are to provide instrumentation to support KSC launch operations, and include: the development of a passive method for determining fluid contamination levels in fluid flow systems, both on-board and ground, is continuing with breadboard testing and evaluation; the automation of minor chemical analytical instrumentation processes is desired to reduce the manpower required, to increase proficiency, and optimize processing equipment requirements to support microchemical sample analyses; determine the correlation between automatic particle counters and the conventional microscope method of counting particles for the determination of contamination levels in flight and ground support equipment; design and build an automated system to electronically trace and verify prepatched patchboards in support of the KSC telemetry station; and improve KSC telemetry station operation reliability and reduce operations personnel through the use of a centralized control console.

W76-70697 **910-21-00**
Marshall Space Flight Center, Huntsville, Ala.
MANUFACTURING AND INSPECTION
J. M. Knadler 205-453-2492

The objective of this effort is to evolve through research, development and technology application studies new nondestructive testing (NDT) nondestructive evaluation (NDE) techniques for application during production, post production, preflight, and post flight refurbishment of space systems hardware such as large space structures, space vehicles, free flying teleoperators, and elements and components, such as thin wall tank structures and composite materials. These techniques must be comprehensive, reliable, fast, and give data which have traceability and reproducibility, along with remote and portable application. Holographic, ultrasonic and acousto-optical techniques and combinations thereof will be investigated in the following tasks: (1) advanced remote visual inspection techniques; (2) holographic theoretical model developments; (3) basic developments in holographic detection; (4) composite mobile holographic nondestructive testing (CMHNDT) system; (5) acousto-optical holographic nondestructive testing (AOHNDT) system; (6) automated holometry fringes inspection and data analysis; (7) refurbishment nondestructive evaluation (NDE); (8) advancement of automated ultrasonic testing.

W76-70698 **910-21-09**
John F. Kennedy Space Center, Cocoa Beach, Fla.
MANUFACTURING INSPECTION
S. D. Wilson 305-867-2758

The objective of this project is to conduct a test program to evaluate the automatic butt welding of flared-type connectors to stainless steel tubing to replace the currently used technique of mechanically flaring heavy-walled stainless steel tubing. The study will include the sample welding of test specimens of stainless steel tubing typically used at KSC, a mechanical test program, a cost-trade study and possible purchase of a tube welding device.

W76-70699 **910-25-00**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED SCHEDULING
R. S. Davis 713-483-4346

The objective of this task 32 is to complete the Phase 2 prototype development and to verify the PLANS language developed in Phase 2 and thus prove its acceptability for operational usage. Specifically, the language data structure, library modules, and language statement capabilities will be tested for operational completeness and efficiency of usage. This will be done through an extensive series of verification programming in

both batch and interactive environments. The language translator will be optimized for the production of PL1 object code in order to increase the execution speed, and a specification will be prepared for the capabilities of a data management system to support PLANS. Also a specification for the interface between the interactive user and the PLANS language will be prepared. The objective of supplemental task 61 is to provide interactive execution capability for the PLANS language being implemented in Phase 2. Displays, input conventions, and tutorial aids to support the language will be developed. A graphics support software will be prepared and the system implemented in Houston. Finally, the Phase 2 demonstration program will be adapted to interactive use and implemented on the system.

W76-70700 **910-27-01**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED SOFTWARE DEVELOPMENT
Mary Ann Goodwin 713-483-4751

This task continues the development of an interactive software program, the Automated Test Data Generator (ATDG), to aid in the verification of computer software by the use of a network analysis of the software logic. The technique was initially conceived as a means of constructing efficient test data. However, experience with the system has suggested the technique of software network analysis has broader application. It is proposed that the present tool be used to evaluate the feasibility of the technique in all areas identified as potential applications, logic error detection, critique of logic construction, modularization, requirement and specification evaluation, and subroutine and unit test design. It is further proposed that the logical development of the tool continue. Areas to be further developed include: (1) extension of manually input and automatically detected constraints; (2) alteration of the path-building algorithm to consider dynamic changes in the network constraints; (3) extension of the analysis to include more than one subroutine; (4) initialization execution of the subroutine being analyzed from ATDG so that the path generated can immediately be executed and then return to ATDG; and (5) simplify operations and improve displays for the interactive environment.

W76-70701 **910-28-00**
Lyndon B. Johnson Space Center, Houston, Tex.
SOFTWARE PROCESSES
C. R. Mains 713-483-3281

The objective of this RTOP is to perform research in data management system techniques leading to the development of tools to aid JSC personnel in implementing new applications, selecting among data management system approaches and evaluating the performance of the applications on the host system. Research is also being performed on new data structuring techniques. One tool is a math model simulator which will simulate various data base structures and access techniques for various host computers and background loads to provide data concerning resource utilization and response time for a particular application. The second tool is a piece of software called the Real Time Simulator which will interface actual data management systems to permit creation of actual data bases on an actual host computer system to provide instrumentation data for use in calibration and validating the math model simulator and user requirements. After construction of these tools, the research will enter a phase of applied research. A comparative analysis of these tools with other methods and techniques for evaluating DMS's and their performance will be accomplished. The purpose of this phase is to further demonstrate the adaptability, accuracy, and accomplishment of original tool objectives by applying them *in an operational environment using real applications and central* computer facility support personnel and services.

W76-70702 **910-28-02**
Marshall Space Flight Center, Huntsville, Ala.
SOFTWARE PROCESSES
Bobby Hodges 205-453-0134

The objective of this effort is the development of techniques and algorithms for the automatic verification/validation of software modules. Current effort places emphasis on analysis of existing techniques and design of a unified system approach to software testing. FY-76 and future efforts are to be directed toward the implementation/application of the techniques. This effort will provide new capabilities for reducing total software testing time without sacrificing confidence in performance, and at the same time improve the cost ratio between hardware/software systems.

W76-70703 **910-29-01**
Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATION/NAVIGATION/TRAFFIC
B. H. Batson 713-483-2981

This RTOP provides for development of prototype hardware for an all-digital television processing and transmission system. Much effort has been directed towards the study of TV digitization, compression, coding, and modulation techniques, but only recently (with the advent of large-scale integrated circuit technology) has an all-digital system appeared truly competitive with conventional analog techniques. It is now felt that an all-digital approach to picture transmission is not only feasible for the shuttle operational era, but that such an approach will have very significant advantages, such as low cost, high reliability, light weight, low power consumption, small volume, and high performance. Two techniques for digitization of television presently appear to be promising for manned spaceflight applications. One of these techniques (Hadamard transform coding) is believed to offer good picture quality at very low bit rates (less than or equal to 8MBPS), but requires moderately complex hardware at both the transmitting and receiving terminals. The other promising technique (adaptive delta modulation with overshoot suppression) also offers good picture quality and has the additional advantage of being very simple to implement. Unfortunately, the required bit rate is relatively high (greater than 20 MBPS), so much of the advantage ostensibly offered by digital television over conventional analog techniques may be lost if delta modulation is used. It is felt that each of the two techniques warrants further investigation, which will include fabrication and testing of laboratory breadboards of actual Hadamard transform and delta modulation hardware.

W76-70704 **910-31-00**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE OPERATIONS TECHNIQUES
Walter Scott 713-483-3458

A four part statement of work has been written for this study. The first part (onboard consumables management) has been completed. Task 2 (ground consumables management) will be completed by September 1975. The third part (Task 3) will define the simulator functional requirements for consumables management, define the required algorithms, and begin the actual software development identified as required in Task 1-3. Task 41 is the development of cryogenics PVT algorithms for space applications. The first year of this program completed the equation-of-state for hydrogen and developed an equation-of-state for ammonia. In as much as the ammonia effort was added, the density explicit functions are deferred slightly. In the second year of the RTOP the contractor will provide a set of computer programs of a density explicit equation-of-state for hydrogen, oxygen, nitrogen, and ammonia which will be in the order of 100 times faster and at least 1/3 smaller in core storage than any model presently existing. Thermodynamic properties of slush hydrogen and oxygen will be initiated this year.

W76-70705 **910-32-01**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED TECHNOLOGY/SUBSYSTEMS
Michael K. Hendrix 713-483-4061

*The objective of this development is the feasibility demonstra*tion through evaluation testing of a low cost, standardized, prototype nonvolatile (information is retained if power to the device is lost) semiconductor memory. This device may be used advantageously in experiments, control systems, and particularly in data management applications where low power, small size, and high reliability are required. The memories will be designed as a standardized functional block which can be assembled into large, low cost, mass memory arrays. This development effort will be conducted in three stages: (1) A study will be made to determine which microelectronic integrated circuit technology best

satisfies the performance, cost, and reliability requirements consistent with the specific data storage applications. The results of this study will define the design requirements for the microelectronic chip. (2) A microelectronic chip will be designed, fabricated, and tested. Key design parameters will be retention time, interrogation time, power dissipation, transient tolerance, and radiation resistance. Evaluation testing of key electronic parameters will verify performance of device and demonstrate its reliable use in higher level assemblies. (3) A microelectronic hybrid assembly (consisting of several nonvolatile chips interconnected on a common substrate) will be designed, fabricated, and tested to the requirements of Spacecraft Data Management Branch/EG6. The results of this testing will prove the feasibility of using the non-volatile microelectronic chip in spacecraft systems.

W76-70706 **910-33-00**
Marshall Space Flight Center, Huntsville, Ala.
INFORMATION MANAGEMENT SYSTEM
R. E. Panciera 205-453-3989

The objective of the Space Ultrareliable Modular Computer effort is to develop low cost reliable aerospace modular computers and computer input output hardware, which are applicable to NASA's future payloads. The main thrust of this effort at this time is to implement, into the current simplex design, adequate reliability by the incorporation of automatic fault detection and correction designs, perform qualification testing, and continue to develop support software. The development of an internally fault tolerant computer must be undertaken immediately for timely integration of future payload information management subsystems such as tug. The objective of the information management effort is to continue to define, develop and space qualify an onboard information management system (IMS) which can best accomplish the requirements of the Space Tug missions. Areas in which analysis and technology developments are required will be identified. The requirements for memory will be determined. A computer, previously developed, under this effort, and computer input output hardware with special monitoring equipment currently under development will be provided for use in the design, development and test of a redundant laser gyro inertial measuring unit.

W76-70707 **910-33-03**
Lyndon B. Johnson Space Center, Houston, Tex.
INFORMATION MANAGEMENT SYSTEMS
Benjamin H. Hood 713-483-5831

This RTOP will determine the feasibility of optical techniques for spacecraft digital data transmission systems similar to the space shuttle data bus system. The use of optical techniques holds promise of improving the cost effectiveness of digital data transmission systems by the inherent immunity of fiber optics to electromagnetic fields resulting from lightning strike, precipitation static, RF transmitters, and power and signal circuits routed in proximity to the fiber bundle. Where secure communications requirements apply, design and test costs should be reduced significantly because the fiber optics bundles will not emanate RF energy and can cross red/black interfaces without shielding. In some cases filtering requirements on associated conventional wiring can be reduced. System design problems arising from normal EMC wire separation requirements would be alleviated, since the fiber optics bundles are not subject to inter-wire capacitive or inductive noise coupling. This should result in a net savings in vehicle volume. It is also expected that the fiber optics bundles would perform functions equivalent to conventional metal conductors with less weight impact. System and equipment level EMC and lightning protection design costs should be less since the fiber optic bundle will not conduct electrical noise, the avoidance of which is a design impact inherent in conventional wire circuitry.

W76-70708 **910-35-00**
Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEMS ENGINEERING APPLICATIONS
W. F. Haldeman 713-483-2931

The objective of this plan is to improve the JSC and NASA capability to use costs and schedules as parameters in future space system design, development, production,and operations. The approach is as follows: (1) methods will be investigated to improve the ability of the agency to include cost as direct design parameter in advanced program planning. This will involve improvement of existing techniques for vehicle design synthesis, and the development of new techniques in high cost hardware areas such as avionics; (2) the in-house cost data and analysis capability for advanced space program estimating purposes will be further developed and maintained, including various subsystems which are applicable to payloads and future space systems. An avionics data base of historical cost, schedule, and technical future space system hardware and software developments will be further developed; and (3) the data base developed for each subsystem will be used to determine relationships between cost, schedules, and readily-known parameters, such as desired technical performance characteristics. These relationships will form the basis for subroutines in the NASA synthesis model.

W76-70709 **910-35-01**
Lyndon B. Johnson Space Center, Houston, Tex.
MANUFACTURING IN SPACE ENVIRONMENT
P. R. Maloney 713-483-3987

The objectives are to initiate the exploitation of the space environment to manufacture at low cost for use in space objects of different characteristics (i.e., curvature, composition, size, thickness, and strength); and demonstrate the ability to use the space environment advantageously in the manufacturing processes. The approach is to use centrifugal force, space vacuum, inert atmosphere, pressure differential, temperature control, electric and magnetic fields, and other physical parameters to form metals and other materials into objects with specific characteristics. The forces of surface tension of most liquids are higher than their cohesive strengths. Theoretically, by virtue of these properties, one could in zero-g, by rotating a spheroid of homogeneous liquid about an axis through its center, cause the spheroid to become oblate. By introducing a gas at the axis of the spheroid, it can be made hollow. By a combination of rotation and gaseous pressurization, a spheroid may be made both oblate and hollow. By controlled variation of this combination in conjunction with temperature and rate of solidification, solid surfaces with specific eccentricities may be fabricated. Electric and magnetic fields may also be employed to determine geometric shapes and molecular patterns.

W76-70710 **910-35-02**
Langley Research Center, Langley Station, Va.
INTEGRATED POWER/ATTITUDE CONTROL SYSTEM FOR SPACE VEHICLE APPLICATIONS
J. E. Stitt 804-827-3745
(506-19-13)

This work will establish the required technology for an Integrated Power/Attitude Control System (IPACS) capable of performing the dual function of power generation and attitude control for a large variety of spacecraft and missions. Results from in-house and contractual efforts are being used to investigate power generation and control capability of IPACS; to generate requirements for critical hardware components; to develop IPACS configurations and control laws; and to define multimission applicability of IPACS to provide low cost modularized vehicle subsystems. Viability of the IPACS concept will be verified through integration of critical hardware components into a laboratory IPACS and through thorough evaluation of this unit in a realistic mission and dynamic environment using LRC static and dynamic test facilities. Associated development programs will be directly coordinated with LeRC, GSFC, JSC, and MSFC. Preliminary problem areas include the impact of reliability, maintainability, failure modes, and system integration on IPACS performance and multimission usage capability; performance limits of composite materials under cyclic stresses and extended-duration vacuum; development of bearings, seals, and lubrication systems capable of long-life at high speeds and under large cyclic loads; development of high power, high-efficiency motor generator units for operation at high speeds; development of high-power, long-life, low-friction slipring assemblies for operation in a vacuum. Solutions to these problems will be verified through hardware tests and simulations, which will determine power generation

capability, control effectiveness, and spinup, spindown cycling effects on system performance.

W76-70711 **910-36-00**
Lyndon B. Johnson Space Center, Houston, Tex.
MECHANICAL SYSTEMS
Richard F. Smith 713-483-3491

The objectives of this RTOP are: (1) to gain additional technology and experience in the application of an ultra low expansion material to the surface of spacecraft windows, as a means of improving structural properties and decreasing spacecraft operational costs; and (2) determine the feasibility of back driving a brushless dc motor to function as an attenuator and as a drive motor for use in future spacecraft docking systems.

W76-70712 **910-37-00**
Marshall Space Flight Center, Huntsville, Ala.
CRYOGENICS
A. L. Worlund 205-453-3864

The basic program objective is to provide an integrated technology base to enable realistic trade studies involving cryogen propellant management subsystem options for the full capability tug. Analytical studies, environmental parameters and component development will be combined to establish design data on performance and reusability. Operational constraints and interface design criteria will be a principal output of the subsystem and system testing. Subsystem concepts will be integrated and tested to identify system interface problem areas and the maintenance/cost relationship. Advanced concepts developed under prior technology programs which have not been applied to flight vehicles, but already have a hardware development history will be utilized. Specific propellant management areas to be assessed in the breadboard include HPI reusability, zero-g propellant acquisition, and low or zero NPSH pumping. The effort will consist of the following: (1) Task 31 propellant management/main tank breadboard; (2) Task 34 thermal acoustic oscillations; and (3) Task 61 high performance insulation development.

W76-70713 **910-38-00**
Marshall Space Flight Center, Huntsville, Ala.
MATERIALS
C. E. Cataldo 205-453-1280

The objective of the effort represented by these tasks involves the development of materials and/or processes that could provide urgently needed advancements in materials technology. Advanced space systems will require materials that provide long life with little degradation. Improved high efficiency, stable thermal control coatings are needed for all future spacecraft. Longer life lubricants are required. A better knowledge of the fracture characteristics of ceramic/glasses will be very helpful in the design of large mirrors and reflectors, as well as the design of viewing ports. For structures such as Tug, fracture mechanics data for thin gauge materials will be required. Better quality weldments are needed for all programs. To accomplish these objectives, the following tasks will be continued: (1) Task 51 porcelain enamel thermal control coating; (2) Task 52 fracture mechanics of ceramic materials; and (3) Task 53 solid film lubricants. Additionally, four new tasks will be a part of this plan, as follows: (4) Task 54 fracture properties of thin gauge tankage alloys; (5) Task 61 puddle physics in pulsed arc welding; and (6) Task 62 ferro fluid bearing lubrication.

W76-70714 **910-38-00**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT OF IMPROVED NONMETALLIC MATERIALS
F. S. Dawn 713-483-2059

This RTOP will result in the development of new spacecraft interior nonmetallic materials capable of meeting rigorous safety and performance requirements. Specifically, durable nonmetallic materials are required which are nonburning and low smoking and low offgassing in spacecraft interior environments while exhibiting a good balance of engineering properties. Programs are specifically geared toward minimum weights through selection of low density materials, improved component design and high performance requiring minimum-thickness usage. Programs reflect high technology leverage for the most part in that they consist of combining untried but already developed materials in new usage applications resulting in substantial yields in improved product performance.

W76-70715 **910-39-00**
Lyndon B. Johnson Space Center, Houston, Tex.
AEROTHERMODYNAMICS
Robert W. Abel 713-483-3852

The Engineering Design Integration (EDIN) Project is an activity sponsored by the Engineering Analysis Division (EAD) aimed at developing a Computer Aided Design (CAD) capability for JSC. The long-range goal of this activity is to achieve the capability to perform the design of the next major funded NASA project throughout the preliminary design process entirely on the computer. The EAD is committed to developing a CAD capability which will span the broadest meaning of CAD by developing and acquiring the software, hardware and support from other JSC organizations esstential to this task. The approach to developing the EDIN computer aided design system has been to make maximum usage of existing software and technology. The EDIN system is outgrowth of the ODIN system developed at Langley Research Center. The strategy has been to develop computer software which enables an engineering team to perform design integration on the computer and make maximum utility of existing analysis programs. The development efforts utilizing 909 funds are centered in three areas: (1) development of CAD capabilities and software, (2) developing technical analysis programs and (3) developing of design integration techniques and demonstrating their applicability through design simulations.

W76-70716 **910-40-00**
Marshall Space Flight Center, Huntsville, Ala.
AEROELASTICITY
R. S. Ryan 205-453-2481

The objective is to improve the accuracy and efficiency in analyzing and testing the dynamic behavior of space vehicles and payloads. There will be developed dependable analytical and emperical methods that will further the development of low cost structures for such as docking vehicles, payloads, and spacecrafts. To accomplish this objective, the following tasks will be performed: (1) recovery of spinning satellite, (2) development of substructure program, (3) effects of damping on mode shapes (4) experimental study of transient liquid motion in orbiting spacecraft (5) solid propellant viscoelastic dynamic model, and (6) statistical energy analysis of complex structures (0/GL).

W76-70717 **910-42-01**
Lyndon B. Johnson Space Center, Houston, Tex.
SIMULATION
Donald W. Lewis 713-483-4371

The purpose of this study is to continue the development/modification of an interactive computer program to interface with the shuttle procedures simulator and thereby provide a tool for the procedures developer, crew training instructor, and the engineering analyst. The digital computer program resides in the CDC 6400 computer and runs in conjunction with the shuttle procedures man-in-the-loop simulator and is used in the definition, verification and modification of advanced manned systems flight techniques and procedures. The RTOP will improve the productivity in the area of the development of flight crew procedures and the display and recording of crew and systems performance measurement data to support shuttle and subsequent advanced manned systems. The program has the capability to record and produce step by step detailed crew procedures from - simulation runs, compare developed procedures with previously stored reference runs, evaluate crew and system performance and produce flight crew checklist documentation for advanced manned systems. Programming concepts and the program organizational structure previously developed and demonstrated on the part task shuttle procedures simulator will be adapted for use on the full mission simulator.

W76-70718 **910-42-02**
Marshall Space Flight Center, Huntsville, Ala.
SIMULATION (ADVANCED HYBRID COMPUTING SYSTEM - AHCS)

R. L. Lawrence 205-453-5935

The objectives are to co-sponsor the design and development of an Advanced Hybrid Computing System (AHCS) with the Army Material Command (AMC) and other government agencies (Air Force, Navy); jointly participate in defining and reviewing the hardware and software requirements and system architecture for the prototype development of the AHCS; and to evaluate these prototypes. The co-sponsoring government agencies will have representation on a technical committee which will contract three studies/hardware and monitor the efforts on these contracts. NASA will transfer funds to AMC for administering the contracts through one central office. A written agreement will be drawn up between the participating agencies' committee members which will delineate the committee functions and the proposed funding transfer. (Optional funding will allow NASA a hardware prototype from this effort.) The tasks are (1) to finalize and issue RFP's; (2) evaluation of approaches as to design of hardware and software; (3) evaluation of software operating system; (4) finalize hardware design; (5) evaluate hybrid prototype operation; and (6) selection of one vendor for final development.

W76-70719 **910-49-01**

John F. Kennedy Space Center, Cocoa Beach, Fla.

METEOROLOGICAL INFORMATION SYSTEMS

R. J. Wojtasinski 305-867-2780

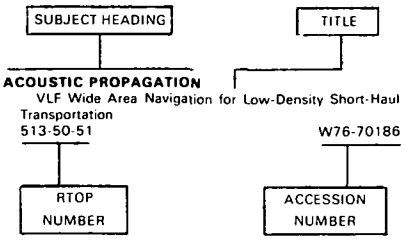
The objective of this effort is the improvement of meteorological forecasting and data gathering, transmission, and analyses at the Kennedy Space Center (KSC). The automation of meteorological data gathering, processing, historical storage, and access for operator usage will be investigated to enhance operating efficiency of the KSC Meteorological Prediction Center.

SUBJECT INDEX

RTOP Summary

FISCAL YEAR 1976

Typical Subject Index Listing



A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

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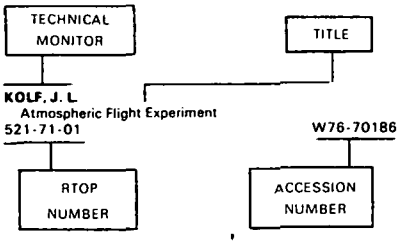

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RESPONSIBLE NASA ORGANIZATION INDEX

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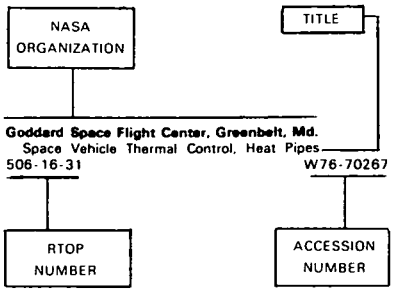

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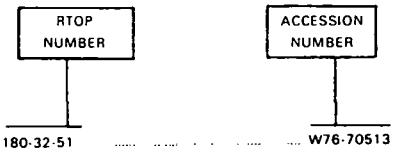

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